EVERYDAY PRACTICAL ELECTRONICS

DECEMBER 1996

http://www.epemag.wimborne.co.uk

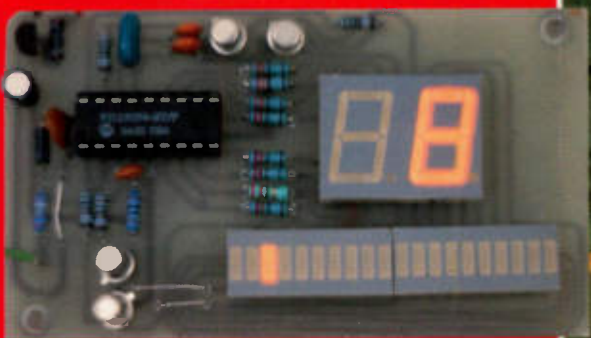
£2.45

VARI-COLOUR CHRISTMAS LIGHTS

Red to Green to Yellow and off in a pseudo random pattern

PIC D/A TACHOMETER

Digital and Analogue Readout of R.P.M.



STEREO CASSETTE RECORDER

Easy to build record/replay p.c.b. project

EPE ELYSIAN THEREMIN

Part 2: Construction and setting up

Plus FULL INDEX FOR VOLUME 25 January to December 1996

THE NO. 1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

MOONSHINE BIBLE 270page book covering the production of alchohol from potatoes, rice, grains etc Drawings of simple home made stills right through to commercial systems. £12 ref MS3

NEW HIGH POWER MINI BUG With a range of 800 metres or more and up to 100 hours use from a PP3 this will be popular! Bug measures less than 1" square! £28 Ref LOT102.

SINCLAIR C5 MOTORS We have a new ones available without gearboxes at £50 ref LOT25

BUILD YOU OWN WINDFARM FROM SCRAP New publication gives step by step guide to building wind generators. Armed with this publication and a good local scrap yard could make you self sufficient in electricity! £12 ref LOT81

PC KEYBOARDS PS2 connector, top quality suitable for all 286/386/486 etc £10 ref PCKB, 10 for £65.

TRACKING TRANSMITTER range 1.5-5 miles, 5,000 hours on AA batteries, also transmits info on car direction and motion! Works with any FM radio. 1.5" square. £65 ref LOT101

ELECTRIC DOOR LOCKS Complete lock with both Yale lock and 12v operated deadlock (keys included) £10 ref LOT99

GALLIUM ARSENIDE FISHEYE PHOTO DIODES Complete with suggested circuits for long range communications\switching £12 complete.

SURVEILLANCE TELESCOPE Superb Russian zoom telescope adjustable from 15x to 60x! complete with metal tripod (imposible to use without this on the higher settings) 66mm lense, leather carrying case £149 ref BAR69

WIRELESS VIDEO BUG KIT Transmits video and audio signals from a minature CCTV camera (included) to any standard television! All the components including a PP3 battery will fit into a cigarette packet with the lens requiring a hole about 3mm diameter. Supplied with telescopic aerial but a piece of wire about 4" long will still give a range of up to 100 metres. A single PP3 will probably give less than 1 hours use. £99 REF EP79. (probably not licensable!)

CCTV CAMERA MODULES 46X70X29mm, 30 grams, 12v 100mA. auto electronic shutter, 3.6mm F2 lens, CCIR, 512x492 pixels, video output is 1v p-p (75 ohm). Works directly into a scart or video input on a tv or video. IR sensitive. £79.95 ref EF137.

IR LAMP KIT Suitable for the above camera, enables the camera to be used in total darkness! £5.99 ref EF138

INFRA RED POWERBEAM Handheld battery powered lamp, 4 inch reflector, krypton bulb, gives out powerful infrared light! 4 D cells required. £39 ref PB1.

MONO VGA MONITORS, Perfect condition, Compaq, 14", 3 months warranty £29 ref MVGA

SOLAR COOKER GUIDE Comprehensive plans

9 WATT CHIEFTAN TANK LASERS

Double beam units designed to fit in the gun barrel of a tank, each unit has two semi conductor lasers and motor drive units for alignement. 7 mile range, full circuit diagrams, new price £50,000? us? £349. Each unit has two gallium Arsenide injection lasers, 1 x 9 watt, 1 x 3 watt, 900nm wavelength, 28vdc, 600hz pulse frequency. The units also contain an electronic receiver to detect reflected signals from targets. five or more units £299 ea. £349 for one. Ref LOT4

TWO WAY MIRROR KIT Includes special adhesive film to make two way mirror(s) up to 60"x20". (glass not included) Includes full instructions. £12 ref TW1.

NEW LOW PRICED COMPUTER/WORKSHOP/HI-FI RCB UNITS Complete protection from faulty equipment for everybody! Inline unit fits in standard IEC lead (extends it by 750mm), fitted in less than 10 seconds, reset/test button, 10A rating. £6.99 each ref LOT5. Or a pack of 10 at £49.90 ref LOT6. If you want a box of 100 you can have one for £250!

RADIO CONTROLLED CARS FROM £6 EACH!!!! All returns from famous manufacturer, 3 types available, single channel (left, right, forwards, backwards) £6 ref LOT1. Two channel with more features £12 ref LOT2.

THOUSANDS AVAILABLE RING/FAX FOR DETAILS!

MAGNETIC CARD READERS (Swipes) £9.95 Cased with flyleads, designed to read standard credit cards! they have 3 wires coming out of the head so they may write as well? complete with control elctronics PCB. just £9.95 ref BAR31

WANT TO MAKE SOME MONEY? STUCK FOR AN IDEA? We have collated 140 business manuals that give you information on setting up different businesses, you peruse these at your leisure using the text editor on your PC. Also included is the certificate enabling you to reproduce (and sell) the manuals as much as you like! £14 ref EP74

PANORAMIC CAMERA OFFER Takes double width photographs using standard 35mm film. Use in horizontal or vertical mode. Complete with strap £7.99 ref BAR1

COIN OPERATED TIMER KIT Complete with coinslot mechanism, adjustable time delay, relay output, put a coinslot on anything you like! TV,s, videos, fridges, drinks cupboards, HIFI, takes 50p's and £1 coins. DC operated. price just £7.99 ref BAR27.

ZENITH 900 X MAGNIFICATION MICROSCOPE Zoom, metal construction, built in light, shrimp farm, group viewing screen, lots of accessories. £29 ref ANAYLT.

AA NICAD PACK Pack of 4 tagged AA nicads £2.99 ref BAR34

PLASMA SCREENS 222x310mm, no data hence £4.99 ref BAR67

NIGHTSIGHTS Model TZS4 with infra red illuminator, views up to 75 metres in full darkness in infrared mode, 150m range, 45mm lens, 13 deg angle of view, focussing range 1.5m to infinity. 2 AA batteries required. 950g weight. £199 ref BAR61. 1 years warranty

LIQUID CRYSTAL DISPLAYS Bargain prices,

16 character 2 line, 99x24mm £2.99 ref SM1623A

20 character 2 line, 83x19mm £3.99 ref SM2020A

16 character 4 line, 62x25mm £5.99 ref SMC1640A

TAL-1 110MM NEWTONIAN REFLECTOR TELESCOPE Russian. Superb astronomical 'scope, everything you need for some serious star gazing! up to 169x magnification. Send or fax for further information ref TAL-1, £249

SOLAR ENERGY/GENERATOR PLANS For your home, loads of info on designing systems etc £7 ref PV1

SOLAR COOKERS Comprehensive guide to building solar powered cookers, includes plans, recipes, cooking times etc £7 ref SBC1

WOLVERHAMPTON BRANCH NOW OPEN AT WORCESTER ST W'HAMPTON TEL 01902 22039

CENTRAL POINT PC TOOLS Award winning software, 1,300 virus checker, memory optimiser, disc optimiser, file compression, low level formatting, backup scheduler, disk defragmenter, undelete, 4 calculators, Dbase, disc editor, over 40 viewers, remote computing, password protection, encryption, comprehensive manual supplied etc £8 ref lot 97 3.5" disks.

GOT AN EXPENSIVE BIKE? You need one of our bottle alarms, they look like a standard water bottle, but open the top, insert a key to activate a motion sensor alarm built inside. Fits all standard bottle carriers, supplied with two keys. SALE PRICE £7.99 REF SA32.

COLOUR CCTV VIDEO CAMERAS, BRAND NEW, CASED, £119.

PERFECT FOR
SURVEILLANCE
INTERNET
VIDEO CONFERENCING
SECURITY
DOMESTIC VIDEO

Works with most modern video's, TV's, Composite monitors, video grabber cards etc Pal, 1v P-P, composite, 75ohm, 1/3" CCD, 4mm F2.8, 500x582, 12vdc, mounting bracket, auto shutter, 100x50x180mm, 3 months warranty, 10 or more £99 ea.

Check out our WEB SITE

http://www.pavilion.co.uk/bull-electrical

GOT AN EXPENSIVE ANYTHING? You need one of our cased vibration alarms, keyswitch operated, fully cased just fit it to anything from videos to caravans, provides a years protection from 1 PP3 battery, UK made. SALE PRICE £4.99 REF SA33.

DAMAGED ANSWER PHONES These are probably beyond repair so just £4.99 each. BT response 200 machines. REF SA30.

IBM PS2 MODEL 160Z CASE AND POWER SUPPLY Complete with fan etc and 200 watt power supply. £9.95 ref EP67

DELL PC POWER SUPPLIES 145 watt, +5,-5,+12,-12, 150x150x85mm complete with switch, flyleads and IEC socket. SALE PRICE £9.99 ref EP55

1.44 DISC DRIVES Standard PC 3.5" drives but returns so they will need attention SALE PRICE £4.99 ref EP68

1.2 DISC DRIVES Standard 5.25" drives but returns so they will need attention SALE PRICE NOW ONLY £3.50 ref EP69

PP3 NICADS Unused but some storage marks. £4.99 ref EP52

DELL PC POWER SUPPLIES (Customer returns) Standard PC psu's complete with fly leads, case and fan. +12v,-12v,+5v,-5v SALE PRICE £1.99 EACH worth it for the bits alone! ref DL1. TRADE PACK OF 20 £29.95 Ref DL2.

GAS HOBS AND OVENS Brand new gas appliances, perfect for small flats etc. Basic 3 burner hob SALE PRICE £24.99 ref EP72. Basic small built in oven SALE PRICE £79 ref EP73

ENERGY BANK KIT 100 6"x6" 6v 100mA panels, 100 diodes, connection details etc. £69.95 ref EF112.

PASTEL ACCOUNTS SOFTWARE, does everything for all sizes of businesses, includes wordprocessor, report writer, windowing, networkable up to 10 stations, multiple cash books etc. 200 page comprehensive manual. 90 days free technical support (01342-326009 try before you buy!) Current retail price is £129, SALE PRICE £9.95 ref SA12. SAVE £120!!!

*SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK

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250 PORTLAND ROAD, HOVE, SUSSEX . BN3 5QT. (ESTABLISHED 50 YEARS).

MAIL ORDER TERMS: CASH, PO OR CHEQUE WITH ORDER PLUS £3 P&P PLUS VAT.

PLEASE ALLOW 7-10 DAYS FOR DELIVERY PHONE ORDERS WELCOME (ACCESS, VISA, SWITCH, AMERICAN EXPRESS)

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FAX 01273 323077
E-mail bull@pavilion.co.uk

RACAL MODEM BONANZA! 1 Racal MPS1223 1200/75 modem, telephone lead, mains lead, manual and comms software, the cheapest way onto the net! all this for just £13 ref DEC13.

BULL TENS UNIT Fully built and tested TENS (Transcutaneous Electrical Nerve Stimulation) unit, complete with electrodes and full instructions. TENS is used for the relief of pain etc in up to 70% of sufferers. Drug free pain relief, safe and easy to use, can be used in conjunction with analgesics etc. £49 Ref TEN/1

PC PAL VGA TO TV CONVERTER Converts a colour TV into a basic VGA screen. Complete with built in psu, lead and s/ware. Ideal for laptops or a cheap upgrade. Supplied in kit form for home assembly. SALE PRICE £25 REF SA34

EMERGENCY LIGHTING UNIT Complete unit with 2 double bulb floodlights, built in charger and auto switch. Fully cased. 6v 8AH lead acid req'd. (secondhand) £4 ref MAG4P11.

YUASHA SEALED LEAD ACID BATTERIES Two sizes currently available this month. 12v 15AH at £18 ref LOT8 and 6v 10AH (suitable for emergency lights above) at just £6 ref LOT7.

ELECTRIC CAR WINDOW DE-ICERS Complete with cable, plug etc SALE PRICE JUST £4.99 REF SA28

AUTO SUNCHARGER 155x300mm solar panel with diode and 3 metre lead fitted with a cigar plug. 12v 2watt. £8.99 REF SA25.

MICRODRIVE STRIPPERS Small cased tape drives ideal for stripping, lots of useful goodies including a smart case, and lots of components. SALE PRICE JUST £4.99 FOR FIVE REF SA26

SOLAR POWER LAB SPECIAL You get TWO 6"x6" 6v 130mA solar cells, 4 LED's, wire, buzzer, switch plus 1 relay or motor. Superb value kit SALE PRICE JUST £4.99 REF SA27

RGB/CGA/EGA/TTL COLOUR MONITORS 12" in good condition. Back anodised metal case. SALE PRICE £49 REF SA16B

PLUG IN ACORN PSU 19v AC 14w , £2.99 REF MAG3P10

13.8V 1.9A PSU cased with leads. Just £9.99 REF MAG10P3

UNIVERSAL SPEED CONTROLLER KIT Designed by us for the C5 motor but ok for any 12v motor up to 30A. Complete with PCB etc. A heat sink may be required. £17.00 REF: MAG17

PHONE CABLE AND COMPUTER COMMUNICATIONS PACK Kit contains 100m of 6 core cable, 100 cable clips, 2 line drivers with RS232 interfaces and all connectors etc. Ideal low cost method of communicating between PC's over a long distance utilizing the serial ports. Complete kit £8.99. Ref comp1.

VIEWDATA SYSTEMS made by Phillips, complete with internal 1200/75 modem, keyboard, psu etc RGB and composite outputs, menu driven, autodialler etc. SALE PRICE £12.99 REF SA18

AIR RIFLES .22 As used by the Chinese army for training puposes, so there is a lot about! £39.95 Ref EF78. 500 pellets £4.50 ref EF80.

VIDEO SENDER UNIT. Transmits both audio and video signals from either a video camera, video recorder, TV or Computer etc to any standard TV set in a 100' range! (tune TV to a spare channel) 12v DC op. Price is £25 REF: MAG15 12v psu is £5 extra REF: MAG5P2

***MINATURE RADIO TRANSCEIVERS** A pair of walkie talkies with a range up to 2 km in open country. Units measure 22x52x155mm. Including cases and earp'ces. 2xPP3 req'd. £30.00 pr. REF: MAG30

***FM TRANSMITTER KIT** housed in a standard working 13A adapter!! the bug runs directly off the mains so lasts forever! why pay £700? or price is £15 REF: EF62 (kit) Transmits to any FM radio.

***FM BUG BUILT AND TESTED** superior design to kit. Supplied to detective agencies. 9v battery req'd. £14 REF: MAG14

GAT AIR PISTOL PACK Complete with pistol, darts and pellets £12.95 Ref EF82B extra pellets (500) £4.50 ref EF80.

6"X12" AMORPHOUS SOLAR PANEL 12v 155x310mm 130mA. SALE PRICE £4.99 REF SA24.

FIBRE OPTIC CABLE BUMPER PACK 10 metres for £4.99 ref MAG5P13 ideal for experimenters! 30 m for £12.99 ref MAG13P1

MIXED GOODIES BOX OF MIXED COMPONENTS WEIGHING 2 KILOS YOURS FOR JUST £5.99

4X28 TELESCOPIC SIGHTS Suitable for all air rifles, ground lenses, good light gathering properties. £19.95 ref R/7.

GYROSCOPES Remember these? well we have found a company that still manufactures these popular scientific toys, perfect gift or for educational use etc. £6 ref EP70

HYPOTHERMIA SPACE BLANKET 215x150cm aluminised foil blanket, reflects more than 90% of body heat. Also suitable for the construction of two way mirrors! £3.99 each ref O/L041.

LENSTATIC RANGER COMPASS Oil filled capsule, strong metal case, large luminous points. Sight line with magnifying viewer. 50mm dia, 86gm. £10.99 ref O/K604.

RECHARGE ORDINARY BATTERIES UP TO 10 TIMES! With the Battery Wizard! Uses the latest pulse wave charge system to charge all popular brands of ordinary batteries AAA, AA, C, D, four at a time! Led system shows when batteries are charged, automatically rejects unsuitable cells, complete with mains adaptor. BS approved. Price is £21.95 ref EP31.

TALKING WATCH Yes, it actually tells you the time at the press of a button. Also features a voice alarm that wakes you up and tells you what the time is! Lithium cell included. £7.99 ref EP26

PHOTOGRAPHIC RADAR TRAPS CAN COST YOU YOUR LICENCE! The new multiband 2000 radar detector can prevent even the most responsible of drivers from losing their licence! Adjustable audible alarm with 8 flashing leds gives instant warning of radar zones. Detects X, K, and Ka bands. 3 mile range, 'over the hill' 'around bends' and 'rear trap facilities. micro size just 4.25"x2.5"x.75". Can pay for itself in just one day! £79.95 ref EP3.

3" DISCS As used on older Amstrad machines. Spectrum plus3's etc £3 each ref BAR400.

STEREO MICROSOPES BACK IN STOCK Russian. 200x complete with lenses, lights, filters etc etc very comprehensive microscope that would normally be around the £700 mark, our price is just £299 (full money back guarantee) full details in catalogue.

WE BUY SURPLUS STOCK FOR CASH

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VOL. 25 No. 12 DECEMBER 1996

EVERYDAY PRACTICAL ELECTRONICS

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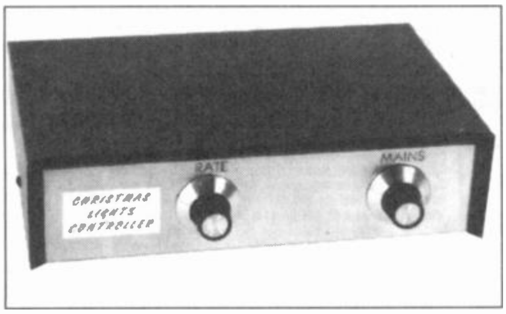
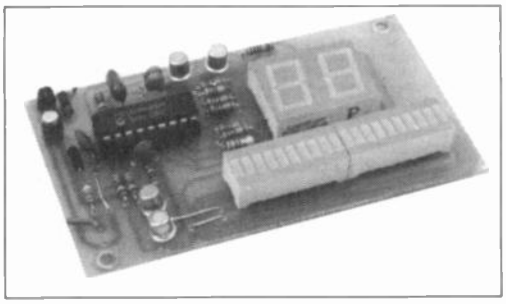
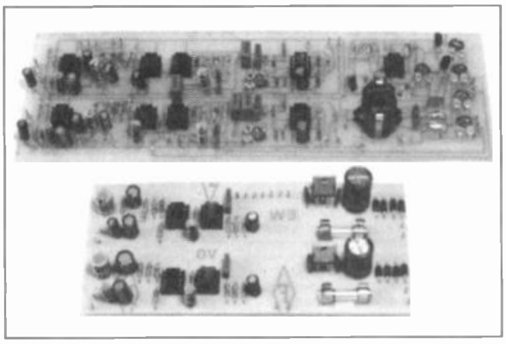
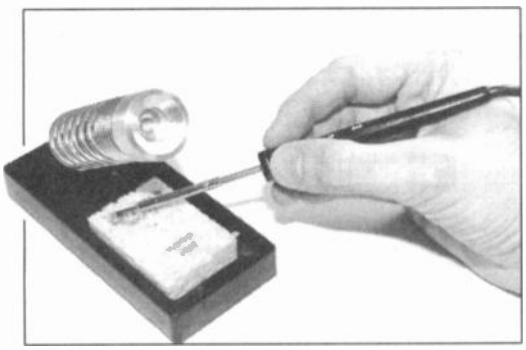
The No. 1 Magazine for Electronics, Technology and Computer Projects









Projects and Circuits

Series and Features

Regulars and Services

1996 INDEX
SEE PAGE 949

Our January '97 issue will be published on Friday, 6 December 1996. See page 929 for details.

Surplus always wanted for cash!

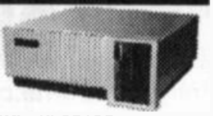
THE *ORIGINAL* SURPLUS WONDERLAND!

THIS MONTH'S SELECTION FROM OUR VAST EVER CHANGING STOCKS

Surplus always wanted for cash!

LOW COST PC's -

SPECIAL BUY
'AT 286'
40Mb HD + 3Mb Ram



LIMITED QUANTITY only of these 12Mhz HI GRADE 286 systems Made in the USA to an industrial specification, the system was designed for *total reliability*. The compact case houses the mother-board, PSU and EGA video card with single 5¼" 1.2 Mb floppy disk drive & Integral 40Mb hard disk drive to the front. Real time clock with battery backup is provided as standard. Supplied in good used condition complete with enhanced keyboard, 640k + 2Mb RAM, DOS 4.01 and 90 DAY Full Guarantee. *Ready to Run !*
Order as HIGRADE 286 ***ONLY £129.00*** (E)

Optional Fitted extras: VGA graphics card	£29.00
1.4Mb 3½" floppy disk drive (instead of 1.2 Mb)	£19.95
Wordperfect 6.0 for Dos - when 3½" FDD option ordered	£22.50
NE2000 Ethernet (thick, thin or twisted) network card	£29.00

LOW COST 486DX-33 SYSTEM

Limited quantity of this 2nd user, supurb small size desktop unit. Fully featured with standard simm connectors 30 & 72 pin. Supplied with keyboard, 4 Mb of RAM, SVGA monitor output, 256k cache and integral 120 Mb IDE drive with single 1.44 Mb 3.5" floppy disk drive. Fully tested and guaranteed. *Fully expandable*
Many other options avaiable - call for details. Only **£399.00** (E)

FLOPPY DISK DRIVES 3½" - 8"

5¼" or 3½" from only £18.95 !

Massive purchases of standard 5¼" and 3½" drives enables us to present prime product at industry beating low prices! All units (unless stated) are ***BRAND NEW*** or removed from often brand new equipment and are fully tested, aligned and shipped to you with a 90 day guarantee and operate from standard voltages and are of standard size. **All are IBM-PC compatible** (if 3½" supported on your PC).

3½" **Panasonic** JU363/4 720K or equivalent RFE	£24.95(B)
3½" **Mitsubishi** MF355C-L. 1.4 Meg. Laptops only	£25.95(B)
3½" **Mitsubishi** MF355C-D. 1.4 Meg. Non laptop	£18.95(B)
5¼" **Teac** FD-55GFR 1.2 Meg (for IBM pc's) RFE	£18.95(B)
5¼" **Teac** FD-55F-03-U 720K 40/80 (for BBC's etc) RFE	£29.95(B)
5¼" **BRAND NEW Mitsubishi MF501B 360K**	£22.95(B)
Table top case with integral PSU for HH 5¼" Flopp or HD	£29.95(B)
8" **Shugart 800/801** 8" SS refurbished & tested	£195.00(E)
8" **Shugart 810** 8" SS HH *Brand New*	£195.00(E)
8" **Shugart 851** 8" double sided refurbished & tested	£250.00(E)
Mitsubishi M2894-63 8" double sided *NEW*	£275.00(E)
Mitsubishi M2896-63-02U 8" DS slimline *NEW*	£285.00(E)
Dual 8" cased drives with integral power supply 2 Mb	£499.00(E)

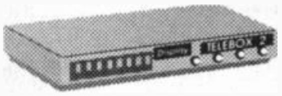
HARD DISK DRIVES

End of line purchase scoop! *Brand new* **NEC D2246 8" 85 Mbyte drive with industry standard SMD interface, replaces Fujitsu equivalent model. Full manual. Only £299.00 or 2 for £525.00 (E)**

3½" FUJI FK-309-26 20mb MFM I/F RFE	£59.95(C)
3½" CONNER CP3024 20 mb IDE I/F (or equiv)RFE	£59.95(C)
3½" CONNER CP3044 40mb IDE I/F (or equiv.)RFE	£69.00(C)
3½" RODIME RO3057S 45mb SCSI I/F (Mac & Acorn)	£69.00(C)
3½" **WESTERN DIGITAL** 850mb IDE I/F *Brand New*	£185.00(C)
5¼" **MINISCRIBE** 3425 20mb MFM I/F (or equiv.) RFE	£49.95(C)
5¼" **SEAGATE** ST-238R 30 mb RLL I/F Refurb	£69.95(C)
5¼" CDC 94205-51 40mb HH MFM I/F RFE tested	£69.95(C)
5¼" HP 9754B 850 Mb SCSI RFE tested	£89.00(C)
5¼" HP C3010 2 Gbyte SCSI *differential* RFE tested	£195.00(C)
8" **FUJITSU** M2322K 160Mb SMD I/F RFE tested	£195.00(E)
Hard disc controllers for MFM , IDE, SCSI, RLL etc. from	£16.95

THE AMAZING TELEBOX

Converts your colour monitor into a QUALITY COLOUR TV!!



TV SOUND & VIDEO TUNER
*CABLE COMPATIBLE**

The **TELEBOX** is an attractive fully cased mains powered unit, containing all electronics ready to plug into a host of video monitors made by makers such as **MICROVITEC, ATARI, SANYO, SONY, COMMODORE, PHILIPS, TATUNG, AMSTRAD** etc. The composite video output will also plug directly into most video recorders, allowing reception of TV **channels not normally receivable on most television receivers*** (TELEBOX MB). Push button controls on the front panel allow reception of 8 fully tuneable 'off air' UHF colour television channels. **TELEBOX MB** covers virtually all television frequencies **VHF and UHF including the HYPERBAND as used by most cable TV operators.** A composite video output is located on the rear panel for direct connection to most makes of monitor or desktop computer video systems. For complete compatibility - even for monitors without sound - an integral 4 watt audio amplifier and low level Hi Fi audio output are provided as standard.

TELEBOX ST for composite video input type monitors	£36.95
TELEBOX STL as ST but fitted with integral speaker	£39.50
TELEBOX MB Multiband VHF/UHF/Cable/Hyperband tuner	£69.95

For overseas PAL versions state 5.5 or 6 mHz sound specification.
*For cable / hyperband reception Telebox MB should be connected to a cable type service. Shipping code on all Teleboxe's is (B)

DC POWER SUPPLIES

Virtually every type of power supply you can imagine.Over 10,000 Power Supplies Ex Stock Call for info / list.

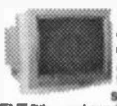
IC's -TRANSISTORS - DIODES

OBSOLETE - SHORT SUPPLY - BULK
6,000,000 items EX STOCK
For ***MAJOR*** **SAVINGS - CALL FOR SEMICONDUCTOR HOTLIST**

VIDEO MONITOR SPECIALS

One of the highest specification monitors you will *ever* see - At this price - Don't miss it!!

Mitsubishi FA3415ETKL 14" SVGA **Multisync** colour monitor with fine 0.28 dot pitch tube and resolution of 1024 x 768. A variety of inputs allows connection to a host of computers including **IBM PC's** in CGA, EGA, VGA & SVGA modes, **BBC, COMMODORE** (including Amiga 1200), **ARCHIMEDES** and **APPLE**. Many features: Etched faceplate, text switching and **LOW RADIATION MPR** specification. Fully guaranteed, supplied in EXCELLENT little used condition.



Tilt & Swivel Base £4.75 **Only £119** (E) Order as MITS-SVGA
VGA cable for IBM PC included.
External cables for other types of computers CALL

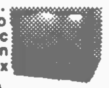
As New - Used on film set for 1 week only!!
15" 0.28 SVGA 1024 x 768 res. colour monitors.
Swivel & tilt etc. Full 90 day guarantee. £145.00 (E)

Just in - Microvitec 20" VGA (800 x 600 res.) colour monitors.
Good SH condition - from £299 - CALL for info

PHILIPS HCS35 (same style as CM8833) attractively styled 14" colour monitor with **both RGB and standard composite 15.625 Khz video inputs** via **SCART socket and separate phono jacks. Integral audio power amp and speaker for all audio visual uses.** Will connect direct to **Amiga** and Atari BBC computers. Ideal for all **video monitoring / security applications with direct connection to most colour cameras.** High quality with many features such as front concealed flap controls, VCR correction button etc. Good used condition - fully tested - guaranteed
Dimensions: W14" x H12¾" x 15½" D. **Only £95** (E)

PHILIPS HCS31 Ultra compact 9" colour video monitor with **standard composite 15.625 Khz video input** via SCART socket. Ideal for all monitoring / security applications. High quality, ex-equipment fully tested & guaranteed (possible minor screen burns). In attractive **square black plastic case measuring W10" x H10" x 13½" D.** 240 V AC mains powered. **Only £79.00** (D)

KME 10" 15M10009 high definition colour monitors with 0.28" dot pitch. Superb clarity and modern styling. Operates from any 15.625 khz sync RGB video source, with RGB analog and composite sync such as Atari, Commodore Amiga, Acorn Archimedes & BBC. Measures only 13½" x 12" x 11". Good used condition. **Only £125** (E)



20" 22" and 26" AV SPECIALS

Superbly made UK manufacture. PIL all solid state colour monitors, complete with composite video & *optional* sound input. Attractive teak style case. Perfect for Schools, Shops, Disco, Clubs, etc.In EXCELLENT little used condition with full 90 day guarantee.

20"....£135 22"....£155 26"....£185 (F)

SPECIAL INTEREST ITEMS

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2kW to 400 kW - 400 Hz 3 phase power sources - ex stock	£POA
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IBM 53F5501 Token Ring ICS 20 port lobe modules	£750
IBM MAU Token ring distribution panel 8228-23-5050N	£95
AIM 501 Low distortion Oscillator 9Hz to 330Khz, IEEE	£550
Trend DSA 274 Data Analyser with G703(2M) 64 i/o	£POA
Marconi 6310 Programmable 2 to 22 GHz sweep generator	£6500
HP1650B Logic Analyser	£3750
HP3781A Pattern generator & **HP3782A** Error Detector	£POA
HP APOLLO RX700 system units	£950
HP6621A Dual Programmable GPIB PSU 0-7 V 160 watts	£1800
HP3081A Industrila workstation c/w Barcode swipe reader	£175
HP6264 Rack mount variable 0-20V @ 20A metered PSU	£675
HP54121A DC to 22 GHz four channel test set	£POA
HP7580A A1 8 pen HPGL high speed drum plotter	£1850
EG+G Brookdeal 95035C Precision lock in amp	£650
View Eng. Mod 1200 computerised inspection system	£POA
Ling Dynamics 2kW programmable vibration test system	£POA
Computer **controlled** 1056 x 560 mm X Y table & controller	£1425
Keithley 590 CV capacitor / voltage analyser	£POA
Racal ICR40 dual 40 channel voice recorder system	£3750
Fiskers 45KVA 3 ph On Line UPS - New batts Dec.1995	£9500
ICI R5030UV34 Cleanline ultrasonic cleaning system	£POA
Mann Tally MT645 High speed line printer	£2200
Intel SBC 486/133SE Multibus 486 system. 8Mb Ram	£1200
Zeta 3220-05 A0 4 pen **HPGL** *fast* drum plotters	£1150
Nikon HFX-11 (Ephiphot) exposure control unit	£1450
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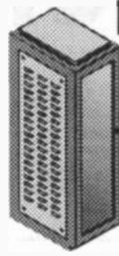
Trio 0-18 vdc linear, metered 30 amp bench PSU. New	£550
Fujitsu M3041R 600 LPM band printer	£1950
Fujitsu M3041D 600 LPM printer with network interface	£1250
Perkin Elmer 2998 Infrared spectrophotometer	£POA
VG Electronics 1035 TELETEXT Decoding Margin Meter	£3750
Andrews LARGE 3.1 m Satellite Dish + mount (For Voyager!)	£950
Sekonic SD 150H 18 channel digital Hybrid chart recorder	£1995
TAYLOR HOBSON Tallysurf amplifier / recorder	£750
System Video 1152 PAL waveform monitor	£485
Test Lab - 2 mtr square quietised acoustic test cabinets	£300
Kenwood 9601 PAL Vectorscope - NEW	£650

Please call for further details on the above items

19" RACK CABINETS



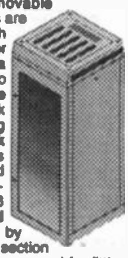
Superb quality 6 foot 40U
Virtually New, Ultra Smart
Less than Half Price!

Top quality 19" rack cabinets made in UK by **Optima Enclosures Ltd.** **Units feature** designer, smoked acrylic lockable front door, full height lockable half louvered back door and louvered removable side panels. Fully adjustable internal fixing struts, ready punched for any configuration of equipment mounting plus ready mounted integral 12 way 13 amp socket switched mains distribution strip make these racks some of the most versatile we have ever sold. Racks may be stacked side by side and therefore require only two side panels to stand singly or in multiple bays.
Overall dimensions are: 77½" H x 32½" D x 22" W. Order as:

OPT Rack 1 Complete with removable side panels.	£335.00 (G)
OPT Rack 2 Rack, Less side panels	£225.00 (G)

32U - High Quality - All steel RakCab

Made by **Eurocraft Enclosures** Ltd to the **highest possible spec**, rack **features all steel construction** with removable side, front and back doors. Front and back doors are **hinged for easy access and all are lockable with five secure 5 lever barrel locks.** The front door is constructed of double walled steel with a **'designer style'** smoked acrylic front panel to enable status indicators to be seen through the panel, yet remain unobtrusive. Internally the rack features fully slotted reinforced vertical fixing **members to take the heaviest of 19" rack equipment.** The two movable vertical fixing struts (extras available) are pre punched for standard 'cage nuts'. A **mains distribution panel** internally mounted to the bottom rear, provides 8 x IEC 3 pin Euro sockets and 1 x 13 amp 3 pin switched **utility socket.** Overall ventilation is provided by fully louvered back door and double skinned top section with top and side louvres. The top panel may be removed for fitting of integral fans to the sub plate etc. Other features include: fitted castors and floor levelers, prepunched utility panel at lower rear for cable / connector access etc. Supplied in excellent, slightly used condition with keys. Colour Royal blue. External dimensions mm=1625H x 635D x 603 W. (64" H x 25" D x 23¾" W)



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A superb buy at only £195.00 (G)

Over 1000 racks **- 19" 22" & 24" wide**
3 to 44 U high. Available from stock !!
Call with your requirements.

TOUCH SCREEN SYSTEM

The ultimate in 'Touch Screen Technology' made by the experts - ***MicroTouch*** - but sold at a **price below cost !!** System consists of a flat translucent glass laminated panel measuring 29.5 x 23.5 cm connected to an electronic controller PCB. The controller produces a **standard serial RS232** or TTL output which continuously gives simple serial data containing positional X & Y co-ordinates as to where a finger is touching the panel - as the finger moves, the data instantly changes. The X & Y information is given at an **incredible matrix resolution of 1024 x 1024 positions over the entire screen size !! A host of available translation software enables direct con**nection to a PC for a myriad of applications including: control panels, **pointing devices,** POS systems, controllers for the disabled or computer un-trained etc etc. Imagine using your finger with 'Windows', instead of a mouse !! (a driver is indeed available !) ***The applications for this amazing product are only limited by your imagination!!*** Complete system including Controller, Power Supply and Data supplied at an incredible price of only: ***£145.00*** (B)
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Half length 8 bit memory upgrade cards for PC AT XT expands memory either 256k or 512k in 64k steps. May also be used to fill in RAM above 640k DOS limit. Complete with data.
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MITSUBISHI MMF-08C12DM 80x80x25 mm 12v DC	£5.25 10 / £49
MITSUBISHI MMF-09B12DH 92x92x25 mm 12v DC	£5.95 10 / £53
PANCAKE 12-3.5 92x92x18 mm 12v DC	£7.95 10 / £69

EX-EQUIP AC fans. ALL TESTED 120 x 120 x 38 mm specify 110 or 240 v £6.95. 80 x 80 x 38 mm - specify 110 or 240 v £5.95
IMHOF B26 1900 rack mnt 3U x 19" Blower 110/240v NEW £79.95
Shipping on all fans (A). Blowers (B). ***50,000 Fans Ex Stock CALL***

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SIGNAL BOX, 3 pilot lamps in white metal case, Order Ref: 3P16.
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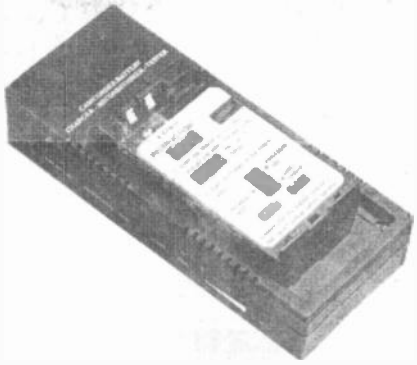
KEYBOARD intended for OPD computer, Order Ref: 3P27.
SOLAR CELL, 750mA, Order Ref: 3P42.
PROJECT BOX with lid, 165mm x 119mm x 75mm, Order Ref: 3P49.
INSTRUMENT TYPE MAINS INPUT SOCKET with built-in filter, Order Ref: 3P50.
6-CORE 5A FLEX, 12m, Order Ref: 3P54.
20V 3A MAINS TRANSFORMER, Order Ref: 3P59.
20V 4A MAINS TRANSFORMER, Order Ref: 3P106.
36V 3A MAINS TRANSFORMER, Order Ref: 3P14.
40V 2A MAINS TRANSFORMER, Order Ref: 3P107.
20V-0V-20V 40VA MAINS TRANSFORMER, Order Ref: 3P205.
½ r.p.m. 2W MOTOR, Order Ref: 3P64.
METAL PROJECT BOX, size 8" x 4½" x 4", made for GPO, Order Ref: 3P74.
THIN CONNECTING WIRE, 2 cores twisted together, full length 500m, Order Ref: 3P78.
12V 1A PSU, filtered and regulated on PCB with relays and Piezo sounder, Order Ref: 3P80.
HORN SPEAKER, 8 ohm 5W, size 4¼", Order Ref: 3P82.
20A TIME SWITCH, ex-electricity board, Order Ref: 3P84.
ABS PROJECT BOX, 145mm x 95mm x 58mm, Order Ref:3P85.
HEAT AND LIGHT LAMP, BC 250W, Order Ref: 3P86.
16-IN-ONE TOOK KIT, Order Ref: 3P100.
RAINBOW PIANO with tune chart, Order Ref: 3P101.
BT INSULATION TESTER, faulty, movement OK so should be repairable. Supplied with circuit diagram, Order Ref: 3P103.
MODERN TELEPHONE HANDSET without dial, cream, Order Ref: 3P104.
3-CORE 20A FLEX, 10M, Order Ref: 3P109.
QUARTZ CLOCK MOVEMENT with hours, minutes and seconds hands and mounting bracket, Order Ref: 3P111.
20W LOUDSPEAKER, 5" 4 ohm by Goodmans, Order Ref: 3P145.
CUPBOARD DOOR ALARM, Order Ref: 3P155.
WATER LEVEL ALARM, fully adjustable, Order Ref: 3P156.
HEAVY DUTY MAINS MOTOR with 2½" spindle each side, Order Ref: 3P157.
RESETTABLE 6-DIGIT 12V COUNTER, Order Ref: 3P158.
0V-10V PANEL METER, Order Ref: 3P159.
6FT MINERAL FILLED METAL CLAD 1000W ELEMENT, Order Ref: 3P161.
TIME AND SET SWITCH for mains at 30A, Order Ref: 3P164.
AMSTRAD 8" 15W WOOFER, Order Ref: 3P167.
12V BRUSHLESS FAN mounted in frame with its own drive circuit, Order Ref: 3P168.
SOLENOID AIR VALVE 110V, Order Ref:3P178.
TRANSFORMER AND RECTIFIER for 12V charger, Order Ref: 3P180.
WALL MOUNTING MAINS THERMOSTAT, Order Ref: 3P182.
5" 8 OHM SPEAKER IN WOODEN CABINET, Order Ref: 3P183.
MULTI-CORE VIDEO LEAD with proper plugs each end, Order Ref: 3P187.
DC PANEL METER, 0V-20V, Order Ref: 3P188.
12μF 660V a.c. CAPACITOR, Order Ref: 3P203.
14μF 400V a.c. CAPACITOR, Order Ref: 3P199.
15μF 440V a.c. CAPACITOR, Order Ref: 3P190.
20μF 440V a.c. CAPACITOR, Order Ref: 3P191.
25μF 370V a.c. CAPACITOR, Order Ref: 3P192.
500μF 350V ELECTROLYTIC CAPACITOR, Order Ref:3P204.
MINI STEPPER MOTOR, 1·5 degree steps, Order Ref: 3P193.
MAINS OPERATED WATER VALVE, suit high or low pressure, Order Ref: 3P192.
AMSTRAD AMPLIFIER, Ref. No. not known, is stereo and has 10 LED's on front panel, Order Ref: 3P195.
HALOGEN LAMP, 12V 20W, Order Ref: 3P200.

£3.50 BARGAIN PACKS

SOLAR CELL, 1A, Order Ref: 3.5P2.
CIRCUIT BREAKER 5A, Order Ref: 3.5P3.
AM/FM RADIO CHASSIS with LCD time, date and alarm display, Order Ref: 3.5P5.
4 13A SOCKET MAINS ADAPTOR, Order Ref: 3.5P9.
METAL CASE, 140mm x 56mm x 110mm, Order Ref: 3.5P10.

CAMCHARGER

CAMCORDER BATTERY QUICK CHARGER (WITH RECONDITIONER & TESTER)



The Camcorder Battery Quick Charger and Discharger with Tester can charge virtually all camcorder batteries. Two methods of charging are available. The discharge/charge mode, under which the unit will automatically discharge and then "quick charge" your battery. The discharging eliminates any battery memory. The charge mode is another selection of charging that will solely give a quick charging function, the test mode tests the capacity status of your camcorder.

The Camcorder Battery Quick Charger and Discharger can be powered by a standard AC outlet or on the road from the cigarette lighter socket in your automobile.

Brand new and boxed, would make a wonderful present. Normal price £35, yours for **£15,** Order Ref: 15P73.

TWO MORE TOROIDAL TRANSFORMERS TO ADD TO THE LIST IN LAST MONTH'S ADVERT
Main difference is that these do not have the fixing bracket.
Order Ref 4P100 is 120VA, has 2 x 27V windings so will give you 4·5A at 27V or 2·25A at 54V, price **£4.**
Order Ref 1·5P47 is 25VA, will give you 24V at 1A or 48V at 0·5A, price **£1.50.**

FOR YOU
An intricate little circuit unit with LCD and an opportunity to earn yourself pocket money, providing you are a customer during November and December you will receive this free!

FLASHING BEACON. Uses an XENON tube and has amber-coloured dome with separate bracket, 12V operated. Price only **£5,** Order Ref: 5P.267.
HIGH RESOLUTION MONITOR. 9" by Philips, in metal frame for easy mounting. Brand new, offered at less than the price of the tube alone, **£15,** Order Ref: 15P1.
15W 8" OHM SPEAKER AND 3" TWEETER. Amstrad, made for their high quality music centre, **£4** per pair, Order Ref: 4P57.
INSULATION TESTER WITH MULTIMETER. Internally generates voltages which enables you to read insulation directly in megohms. The multimeter has four ranges, AC/DC Volts, 3 ranges milliamps, 3 ranges resistance and 5 amp range. These instruments are ex-British Telecom but in very good condition, tested and guaranteed OK, probably cost at least **£50,** yours for only **£7.50** with leads, carrying case **£2** extra, Order Ref: 7.5P4.
We have some of the above testers but slightly faulty, not working on all ranges, should be repairable, we supply, diagram, **£3,** Order Ref: 3P176.
250W LIGHT DIMMER. Will fit in place of normal wall switch, only **£2** each, Order Ref: 2P380. Note these are red, blue, green or yellow but will take emulsion to suit the colour of your room. *Please state colour required.*
LCD 3½" DIGIT PANEL METER. This is a multi-range voltmeter/ammeter using the A-D converter chip 7106 to provide five ranges each of volts and amps. Supplied with full data sheet. Special snip price of **£12,** Order Ref: 12P19.
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£7 BARGAIN PACKS

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RECORD PLAYER, BSR linear model. New with pick-up but less control panel, with panel details, Order Ref: 7P11.
WOODS CIRCULAR FAN, 6½" ex-computer but tested and guaranteed, Order Ref: 7P16.
SOLAR KITS, make helicopter, Order Ref: 7P17; make monoplane, Order Ref: 7P18; make old world gramophone, Order Ref: 7P20.
POWER SUPPLY CASE, nickel-plated steel, size approximately 15½" × 5" × 2½", Order Ref: 7P21.
36-CORE CABLE, each core takes 8A at mains voltage, 5m length, Order Ref: 7P22.
CAR BATTERY CHARGER KIT, complete with metal case, Order Ref: 7P23.

£8 BARGAIN PACKS

83MM SQUARE AXIAL FAN, mains operated, by German PAPST, Order Ref: 8P35.
SOLAR EDUCATIONAL KIT, makes fan, etc, Order Ref: 8P42.
SOLAR CHARGER for AA batteries, Order Ref: 8P43.
MULLARD AMPLIFIER, 4 Unilex modules, Order Ref: 8P44.
LCD DISPLAY. 2 lines, Epsom ref. X16027AR, Order Ref: 8P48.
80A TIME SWITCH, ex-electricity board, Order Ref: 8P62.
0V-15V D.C. PANEL METER, Order Ref: 8P53.
1/8HP 12V D.C. MOTOR, Order Ref: 8P54.
5 r.p.m. 60W MAINS MOTOR, Order Ref: 8P55.
150 r.p.m. 60W MAINS MOTOR, Order Ref: 8P57.
ITT STEREO AMPLIFIER, 10W + 10W with radio panel, Order Ref: 8P62.

£8.50 BARGAIN PACKS

ASTEC SWITCH-MODE PSU, gives 38V and 5V, total 110W, Order Ref: 8.5P2.
20,000 OPV MULTI TESTER, ex-BT, complete with prods, reconditioned and guaranteed, Order Ref: 8.5P3.

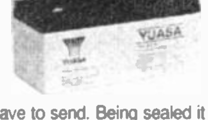
£9 BARGAIN PACKS

FIVE E180 VIDEO TAPES, Order Ref: 9P6.
VIBRATING REED FREQUENCY METER, 55Hz-65Hz, Order Ref: 9P8.
BUMP 'N GO SPACESHIP KIT, Order Ref: 9P9.
10 TDK AUDIO TAPES, Order Ref: 9P12.
2-TONE HORN KIT, Order Ref: 9P15.
4 OCTAVE KEYBOARD, piano size keys, Order Ref: 9P16.

£10 BARGAIN PACKS

100A TIME SWITCH, ex-electricity board, reconditioned, Order Ref: 10P14.
MAXIMUM DEMAND INDICATOR, 230V A.C., Order Ref: 10P15.
TANGENTIAL BLOWER FAN, 28" long fan with motor in middle, Order Ref: 10P16.
POWER STATION TYPE VOLTMETER, in 6" diameter metal case, Order Ref: 10P25.
ALUMINIUM CASE, 19½" × 12½" × 8", very good condition, Order Ref: 10P40.
BULKHEAD SPEAKER, metal case with fixing bracket, 8 Ohm, Order Ref: 10P43.
POWERFUL WATER PUMP, operated by heavy duty mains motor, Order Ref: 10P76.
DOUBLE BLOWER, mains operated, suit greenhouse or workshop, Order Ref: 10P84.
FLUORESCENT CONVERTER by Philips for 3" × 9" tubes, Order Ref: 10P89.
COMPUTER DRIVER, MS-DOS 4.01, Order Ref: 10P99.
MOTORISED DISPLAY, 12 × 10A microswitches, driven by mains motor, Order Ref: 10P101.
CRT ref. SE5J31, 6", Order Ref: 10P104.
HOT WIRE PANEL METER, 6", Order Ref: 10P106.
DATA RECORDER, Sharp ref. 1T400, Order Ref: 10P110.
SOLENOID WATER VALVE, Danfoss, 12V D.C. or 24V A.C., Order Ref: 10P118.
POWERFUL STEPPER MOTOR, 7·5 degree angle, American Philips, 12V-14V, Order Ref: 10P128.
MONITOR, black and white, 4871, ex-equipment but guaranteed, Order Ref: 10P131.
POWER RELAY, 4 × 10A changeover contacts, Order Ref: 10P136.

YOU SAVE £40



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A versatile thermostat using a thermistor probe and having an l.c.d. display. MIN/MAX memories, −10 to 110 degrees Celsius, or can be set to read in Fahrenheit. Individually settable upper and lower switching temperatures allow close control, or alternatively allow a wide 'dead band' to be set which can result in substantial energy savings when used with domestic hot water systems. Ideal for greenhouse ventilation or heating control, aquaria, home brewing, etc. Mains powered, 10A SPCO Relay output. Punched and printed case.

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Our very popular project – now with ready built probe assembly and diecast box. Picks up vibrations amplifies, and drives headphones. Sounds from engines, watches, and speech through walls can be heard clearly. Useful for mechanics, instrument engineers and nosey parkers! A very useful piece of kit.

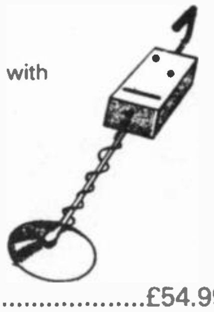
KIT 856........................£29.95

WINDICATOR

A novel wind speed indicator with LED readout. Kit comes complete with sensor cups, and weatherproof sensing head. Mainspower unit £5.99 extra.

KIT 856..£28.00

BUCCANEER I.B. METAL DETECTOR



An Induction Balance (I.B.) detector with audible output. Providing good sensititivy and easy construction.
COMPLETE KIT – INCLUDES ALL HARDWARE, HANDLE, SEARCH HEAD, PCB etc.
CIRCUIT REJECTS IRON WHILST PICKING UP GOLD, SILVER, COPPER etc.
A SOLID RELIABLE DESIGN.

KIT 719..£54.99

1000V & 500V INSULATION TESTER

Superb new design. Regulated output, efficient circuit. Dual-scale meter, compact case. Reads up to 200 Megohms. Kit includes wound coil, cut-out case, meter scale, PCB & ALL components.

KIT 848...................£32.95

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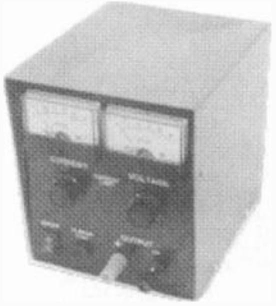

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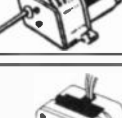

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2N3053	£0.27
2N3054	£0.85
2N3055	£0.58
2N3439	£0.62
2N3440	£0.50
2N3702	£0.09
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2N3704	£0.10
2N3705	£0.10
2N3706	£0.10
2N3771	£1.44
2N3772	£1.51
2N3773	£1.70
2N3819	£0.42
2N3820	£0.66
2N3904	£0.10
2N3905	£0.10
2N3906	£0.10
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2N5296	£0.57
2N5321	£0.57
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33	£0.05	—	£0.05	—	—
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4.7	—	—	—	£0.13	—	—	£0.41
10	£0.12	—	£0.12	£0.13	£0.17	£0.40	£0.51
22	£0.12	£0.13	£0.14	£0.15	£0.21	£0.52	£1.06
33	—	—	—	—	—	—	—
47	£0.13	£0.13	£0.15	£0.19	£0.32	£0.57	—
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220	£0.19	£0.20	£0.27	£0.39	£0.48	—	—
330	—	—	—	—	—	—	—
470	£0.24	£0.28	£0.43	£0.53	—	—	—
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QUESTIONS, QUESTIONS

First of all my thanks to all those readers who have returned last month's Readership Survey forms – if you still have one to fill in we would appreciate its early return. These will help us to shape the future of the magazine to meet your needs. Having said that, it is sometimes amazing to see the widely differing opinions on certain regular features; some people love them, some hate them and plenty are in between. It just goes to show that you cannot please all of the people all of the time.

Your general response has, however, been very positive and we have also received some thought provoking ideas for future projects. Please be assured that your extra comments and suggestions have all been read by myself and, once the number crunching is over, I will also be pouring over the final results for your collective verdict on all aspects of *EPE*.

TAKE YOUR PIC

One point that I have noticed from the questionnaire is that a number of readers feel that they cannot build PIC based projects unless they have a computer. In virtually all cases **this is not true.** Whilst we try to make the PIC software available free (or for a very small charge) for those who can program their own chips, we also try to make sure preprogrammed chips are available for those who just want to build the project with what amounts to a dedicated chip.

The *PIC Digital and Analogue Tachometer* in this issue is just such a project. It can be built as a straightforward design for those with no interest in the software aspect, or it can be programmed for a variety of applications for those with the inclination and equipment. The software, like that for most of our projects, is available free from our **ftp** site on the Internet, or it can be obtained on disk (together with software for seven previous projects) from the editorial offices for a handling charge of just £2.50 (see page 945 for more details on both of these options – also see this month's *Net Work* page).

We try not to take up pages and pages of our valuable magazine space with printouts of the software, as this is only of interest to a relatively small percentage of readers, but it is usually readily available to those who want it. In this way we can ensure that we get the maximum amount of information into the magazine *and* that we provide free (or nearly free) software whenever possible.

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VARI-COLOUR CHRISTMAS TREE LIGHTS

ROBERT PENFOLD

Light-up your tree with ever - changing colours this festive season.

THE electronically controlled Christmas tree lights featured here consist of a string of ten or twelve tri-colour light emitting diodes (l.e.d.s). A range of colourful effects can be produced, and standard flashing Christmas tree lights simply do not bear comparison to this system. The basic effect is for the lights to be cycled through red, green, yellow and off in a pseudo random fashion.

A tri-colour l.e.d. is basically just a green l.e.d. and a red type housed in the same case, with their light output directed at a single diffuser. As one would expect, red or green light is produced if one or other of the l.e.d.s is switched on. If both l.e.d.s are switched on at once, their light output mixes to produce yellow/orange light. By altering the relative strengths of the two l.e.d.s, the exact colour of the light can be varied from a very red-orange through to a green-yellow colour.

LIGHT FANTASTIC

The electronics at the heart of this "lights show" is basically just two low frequency triangular oscillators, one driving the red l.e.d.s and the other driving the green ones. A triangular waveform gives a steady variation from zero to full brightness and back again.

One of the oscillators operates at a fixed frequency of about one Hertz, but the other has an adjustable output frequency. Its approximate frequency range is one cycle every 2·5 seconds to a little over four Hertz.

Example output waveforms for the oscillators are shown in Fig. 1. In this case the oscillator driving the green l.e.d.s is operating at three times the frequency of the one controlling the red l.e.d.s.

The colours produced at various points in the sequence are also shown in Fig. 1. Even with one oscillator operating at a frequency which is an exact multiple of the other oscillator's frequency, and a convenient phase relationship between the two, the sequence of colour changes is quite involved.

Results are best if the oscillators are set at frequencies which do not have such a convenient mathematical relationship. This gives a display which varies in brightness at a rate which is controlled by the higher frequency oscillator, but the colour variations are apparently rather random.

In truth the colour patterns will always repeat, but over a long period of time, giving an apparent randomness to the display. The effect is hard to describe, but the complex and continuous variations in colour make a simple flashing light display look rather pedestrian by comparison.

CIRCUIT DESCRIPTION

The main circuit diagram for the Vari-Colour Christmas Tree Lights appears in Fig. 2, and the mains power supply circuit is shown separately in Fig. 3.

A dual operational amplifier, IC1, is utilized in a conventional triangular/squarewave oscillator. IC1a acts as the integrator and provides the triangular output signal, while IC1b is used as the trigger and provides a squarewave signal. In this case it is only the triangular waveform that is needed, and the output signal of IC1b is unused.

Maximum efficiency is usually obtained by driving large numbers of l.e.d.s in series. Unfortunately, in this case *series* connection is *not* an option.

Tri-colour l.e.d.s invariably seem to have either a common cathode (k) or a common anode (a) connection, and the l.e.d.s used in this design are of the common cathode variety. Series connection is only possible if the anode and cathode terminals are individually accessible.

DRIVING FORCE

The l.e.d.s must therefore be driven in *parallel*, which inevitably means that quite high output currents are involved. A drive current of about 20 milliamps per l.e.d. is needed in order to give really good brightness, which gives a total drive current of 200 milliamps (200mA) for a bank of ten l.e.d.s.

This current is far higher than IC1a can supply, and the l.e.d.s (D1a to D10a) are therefore driven via transistor TR1, which

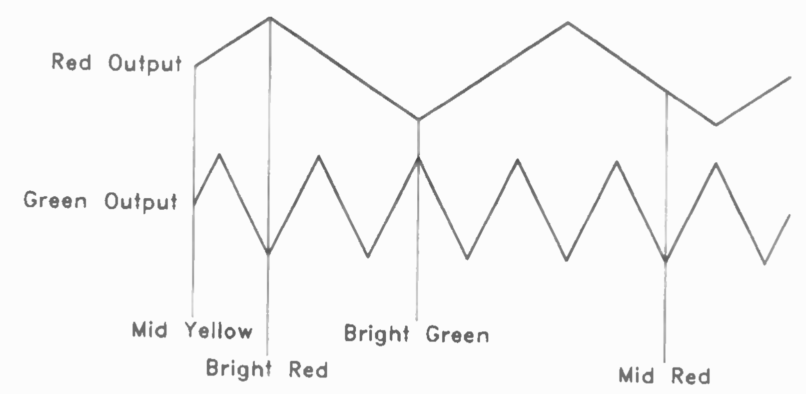


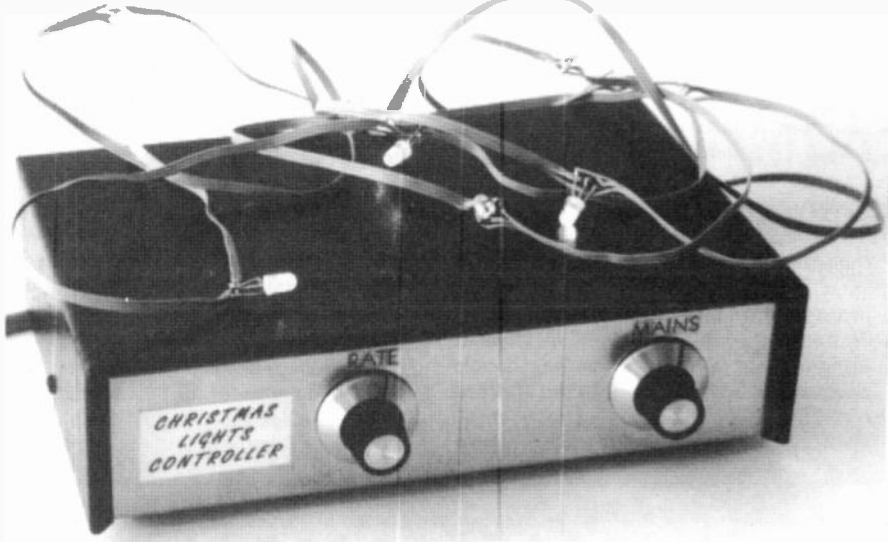
Fig. 1. Example output waveforms and colours.

operates as an emitter follower buffer stage. Transistor TR1 is actually a power Darlington device which can easily supply output currents of 200mA or so, even though IC1a can provide an output current of only a few milliamps.

Ideally, each l.e.d. would be driven via its own current limiting resistor. This is impractical as it would require each l.e.d. to be fed from the controller via a separate lead.

In order to avoid a complete "rats nest" of wires it is necessary to use a method of connection that enables the l.e.d.s to be interconnected via a single cable that runs from one light to the next. Experiments showed that there was no problem if the l.e.d.s are fed via a common current limiting resistor (R6) provided they are *all* of the same type.

The circuit seems to regulate itself so that the current through each l.e.d. is more or less the same, and there is no obvious difference in the brightness of the lights.



Completed controller with "lights" chain.

VARIABLE FREQUENCY

The other sections of the l.e.d.s (D1b to D10b) are driven from another triangular/squarewave oscillator and buffer amplifier, but this circuit has a variable output frequency. This is achieved by using a rotary potentiometer VR1, wired as a variable resistor, as part of the timing resistance.

The maximum frequency of about four Hertz is achieved with VR1 set at minimum resistance, running through to the minimum frequency of around 0·4Hz with VR1 at maximum resistance.

POWER SUPPLY

The mains power supply circuit (Fig. 3) is of conventional design. Mains transformer T1 provides a voltage step-down and isolation from the dangerous mains supply. Full-wave bridge rectification is provided by rectifier diodes D11 to D14, and the supply is smoothed by the high value electrolytic capacitor C4.

A monolithic voltage regulator, IC3, stabilises the output potential at eight volts. The supply current to the main circuit varies from about 10mA with all the lights switched off, to a little over 400mA with both sections of all ten lights at maximum brightness.

CONSTRUCTION

A stripboard having 52 holes by 26 copper strips accommodates most of the components. This is not a standard size in which the board is sold, and a larger piece must be trimmed to the correct size using a hacksaw.

The circuit board topside component layout and interwiring details are given in Fig. 4. Also included is an underside view showing the positioning of the 34 breaks required in the copper strips.

Start construction by drilling the two mounting holes, which should be about 3·3mm in diameter. Three holes of the same size are also needed where TR1, TR2, and IC3 will eventually be bolted to the board.

Next the numerous breaks should be made in the copper strips, using either a special track-cutting tool or a hand-held twist drill bit of about five millimetres in diameter. Make sure that each break covers the full width of the strip, but try to avoid cutting too deeply into the board (which could weaken it significantly).

The board is now ready for the components and 14 link-wires to be fitted. It is best to work methodically across the board, being careful not to omit anything.

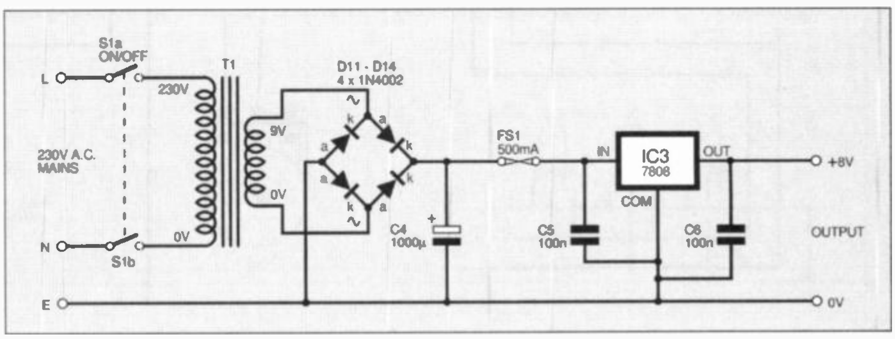


Fig. 3. Circuit diagram for the 8V mains power supply.

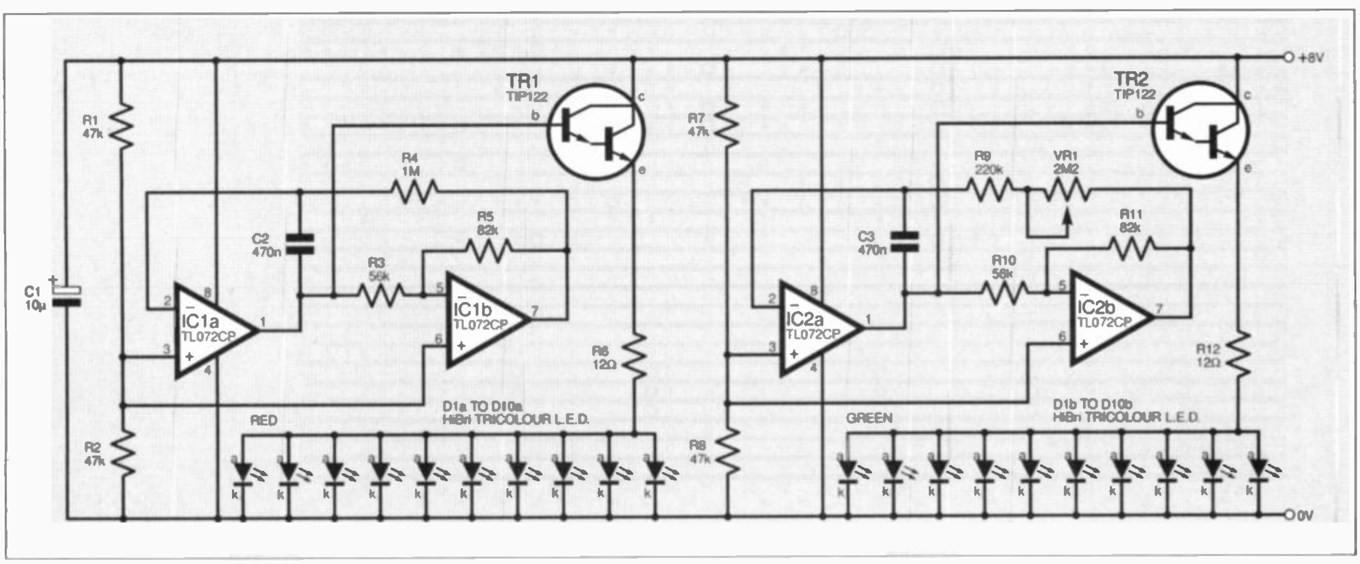


Fig. 2. Main controller circuit diagram for the Vari-Colour Christmas Tree Lights.

Op.amps IC1 and IC2 are not MOS devices and do not require any special handling precautions, but it is still advisable to fit them to the board via d.i.l. holders. Capacitors C2 and C3 must be miniature printed circuit mounting types having 7·5mm (0·3 inch) lead spacing if they are to fit neatly into this component layout.

Be careful to fit the electrolytic capacitors C1 and C4 the right way round as a mistake here could result in the incorrectly fitted component being destroyed (probably in spectacular fashion). For the same reason, double check that diodes D11 to D14 are all fitted correctly. The link-wires can be made from 22s.w.g. or 24s.w.g. tinned copper wire, or trimmings from the resistor leadout wires might suffice.

The amount of power dissipated by TR1, TR2, and IC3 is not very large, but it is advisable to fit them with small bolt-on heatsinks. The heatsinks used on the prototype are somewhat larger than necessary, and the smallest of ready-made heatsinks for TO220 cased devices should be perfectly adequate. The screws which hold the heatsinks in place are also used to secure the components to the circuit board.

To complete the circuit board, fit single-sided solder pins at the points where connections VR1, T1, etc. will be made. "Tin" the tops of the solder pins with plenty of solder, as this will make it easier to produce reliable connections to them.

CASE

For reasons of safety this project must be housed in a *metal* case which has a screw fitting lid, and not one that simply clips on and unclips. The case *must* be reliably "earthed" to the mains Earth lead.

A mains powered project such as this is not suitable for beginners unless they are closely supervised by someone who is suitably experienced at electronic project construction.

A metal instrument case is probably the best choice for this project, and one about 200mm (8in.) or so wide should comfortably accommodate everything. Switch S1 is mounted well towards the left-hand end of the front panel (rear view), and potentiometer VR1 is fitted at any desired

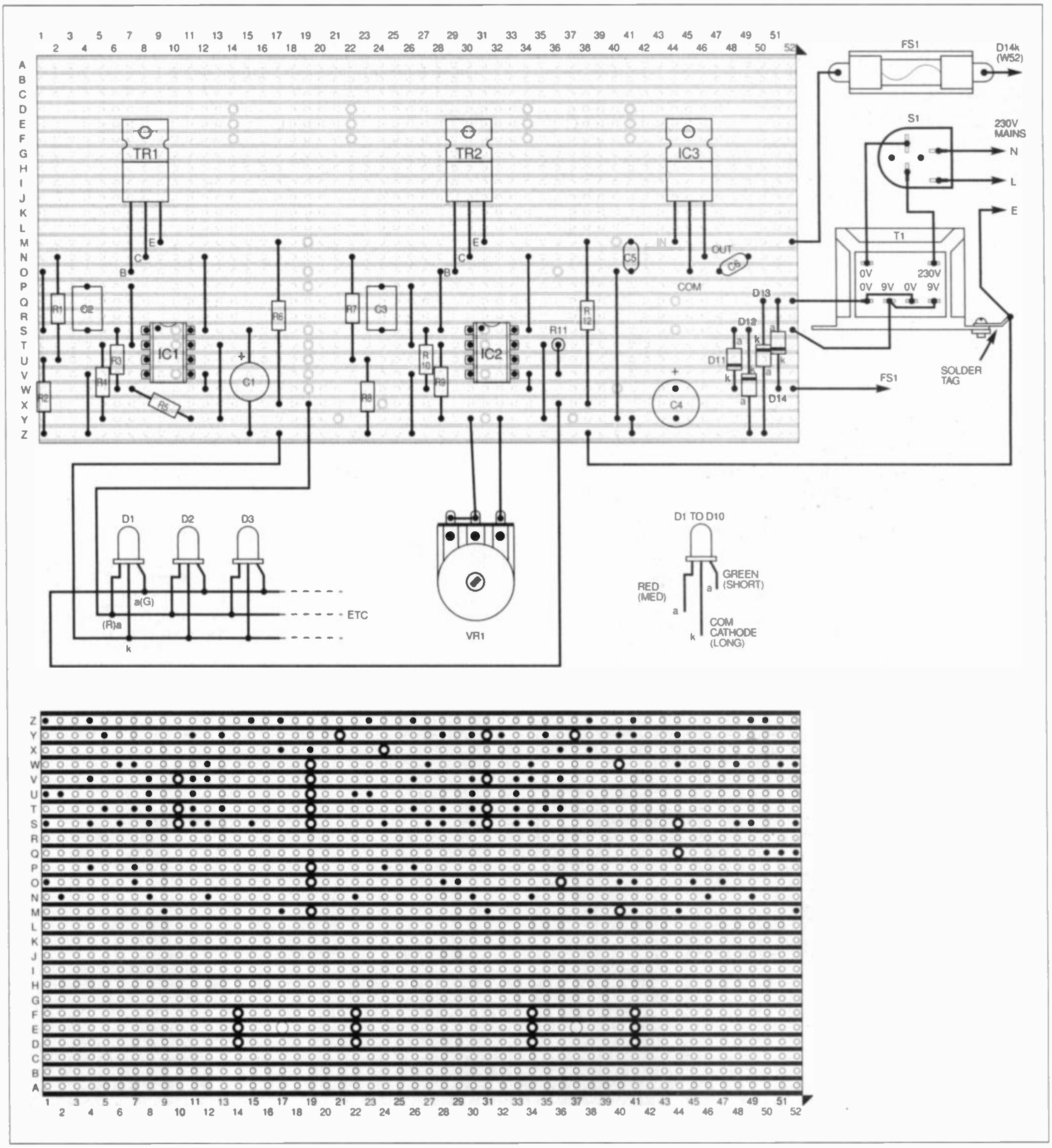
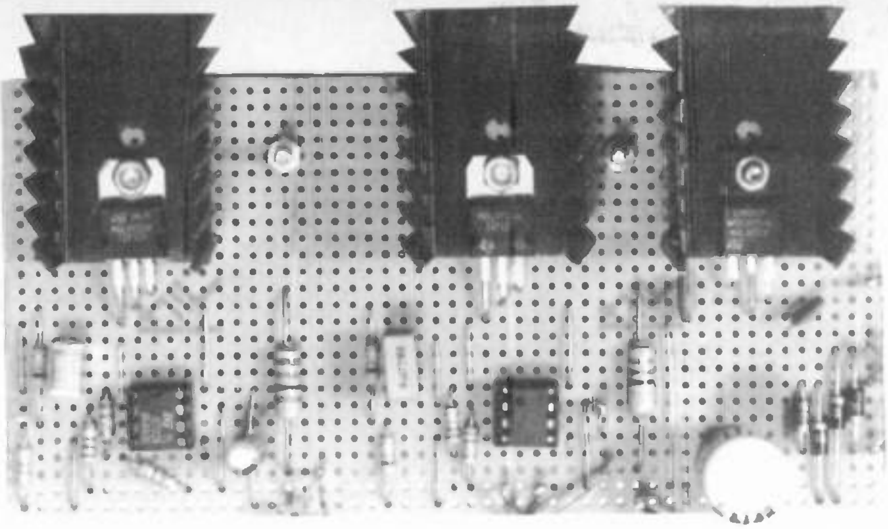


Fig. 4. Vari-Colour Christmas Tree Lights stripboard component layout, underside showing breaks in copper strips and interwiring to off-board components. The pinout details for the tri-colour l.e.d. is shown inset.



Completed circuit board showing the Darlington transistors bolted to heatsinks.

position on the right-hand section of the panel (rear view). The circuit board is mounted well towards the right-hand side of the case, which should leave ample space for transformer T1 to its left (as viewed in the internal photograph).

Mount the circuit board on the base panel using 6BA or metric M3 screws, using spacers about 12mm long to hold the board well clear of the case. This should ensure that there is no danger of the fixing screws for the outer casing damaging or "short circuiting" the board.

Also be careful to position the mains transformer T1 where it will not be damaged by these screws. A solder tag is fitted on one of T1's mounting bolts, and this acts as an Earth connection point for the case.

A hole for the mains lead is made in the rear panel of the case, roughly opposite mains on/ff switch S1. This hole *must* be fitted with a "strain relief" type grommet and the connecting leads securely anchored to protect the mains cable from young prying fingers, particularly at this seasonal time of year.

Fuse FS1 is fitted in a chassis mounting fuseholder which is bolted to the base panel of the case to the rear of T1. Alternatively, a panel mounting fuseholder can be mounted on the rear panel of the case, next to the entrance hole for the mains lead.

The output of the unit can be connected to the l.e.d. "light chain" via a three-way socket fitted on the rear panel, but direct connection is used on the prototype. This requires a hole for the output lead in the rear panel, and this hole should also be fitted with a grommet to protect the cable.

INTERWIRING

The "hard wiring", apart from the connections to the l.e.d.s, is also shown in Fig. 4. The wiring is very straightforward, but it is essential to take ***extra care*** with

COMPONENTS

See SHOP TALK Page

Resistors

R1, R2, R7, R8	47k (4 off)
R3, R10	56k (2 off)
R4	1M
R5, R11	82k (2 off)
R6, R12	12Ω 0·5W (2 off)
R9	220k

All 0·25W 5% carbon film, unless stated

Potentiometer

VR1	2M2 rotary carbon, lin

Capacitors

C1	10µ radial elect. 25V
C2, C3	470n polyester, 7·5mm lead spacing (2 off)
C4	1000µ radial elect. 25V
C5, C6	100n disc ceramic

Semiconductors

D1 to D10	5mm common cathode, high brightness, tri-colour l.e.d. (10 off)
D11 to D14	1N4002 100V 1A rectifier diode (4 off)
TR1, TR2	TIP122 or TIP 121 *npn* power Darlington (2 off)
IC1, IC2	TL072CP bifet dual low-noise op.amp (2 off)
IC3	µA7808 8V 1A positive regulator

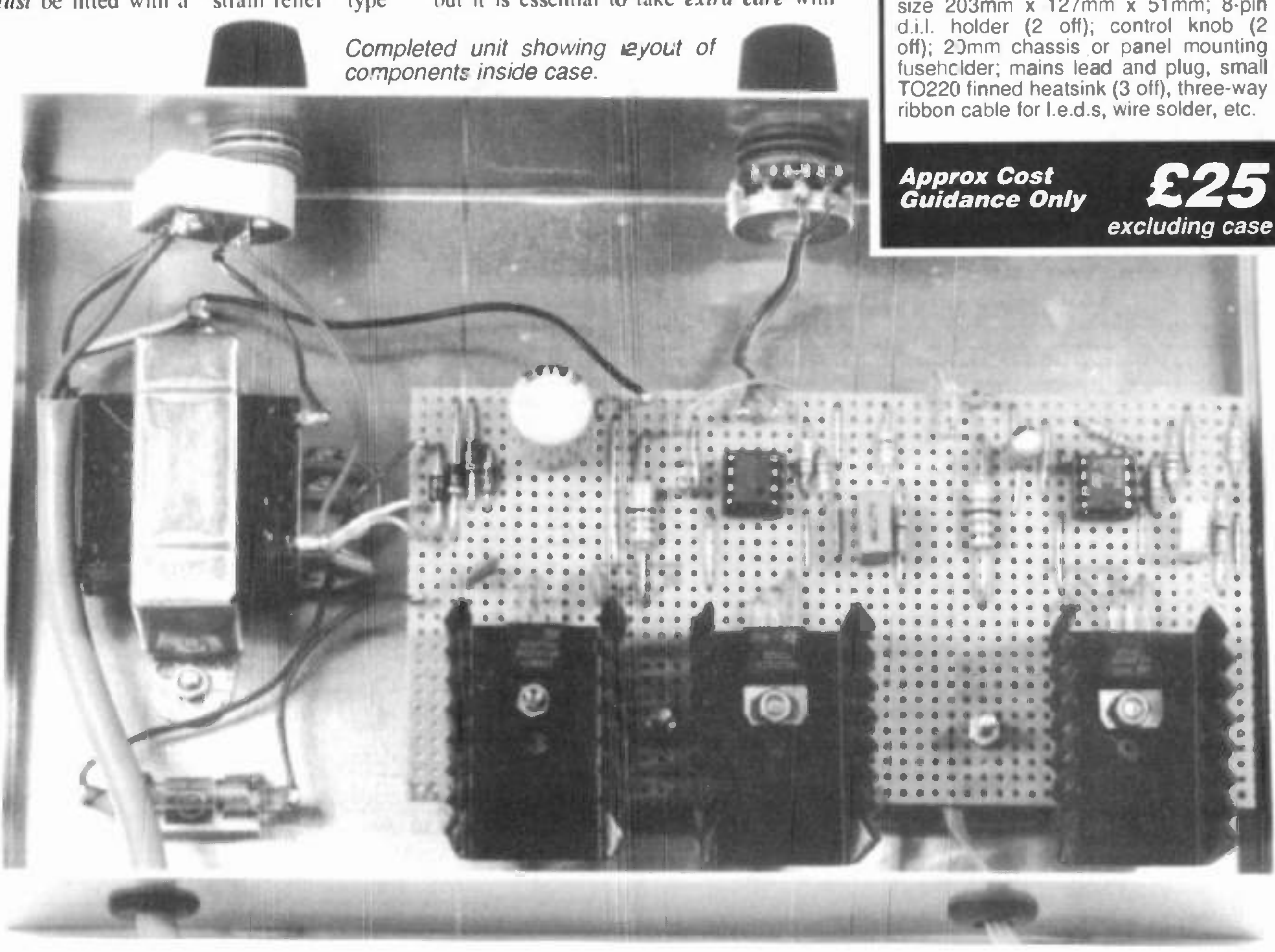
Miscellaneous

T1	standard mains primary, 9V 666mA secondary (see text)
S1	rotary mains switch
FS1	500mA 20mm "quick-blow" fuse

Stripboard 0·1 inch matrix, size 52 holes x 26 strips; metal instrument case, size 203mm x 127mm x 51mm; 8-pin d.i.l. holder (2 off); control knob (2 off); 20mm chassis or panel mounting fuseholder; mains lead and plug, small TO220 finned heatsink (3 off), three-way ribbon cable for l.e.d.s, wire solder, etc.

Approx Cost Guidance Only £25 *excluding case*

Completed unit showing layout of components inside case.



the wiring to the mains transformer T1 and on/off switch S1. Mistakes here could cause costly damage, and could also be very dangerous. Make quite sure that the connections to the Earth solder tag are reliable, and resolder the joint if it seems at all dubious.

A mains transformer having a 9V secondary winding rated at about 666mA is required. These days virtually all small mains transformers seem to have twin secondary windings.

The specified transformer has twin 9V 333mA secondary windings which are connected in parallel, as shown in Fig. 4. This effectively gives a single 9V 666mA winding. *Note that this method of connection must only be used with transformers that have accurately matched secondaries* ***that are designed for parallel connection.***

LIGHTING CHAIN

The l.e.d.s are wired together using a length of thin three-way cable. Grey ribbon cable is a good choice, and a three-way strip is easily peeled off a wider piece.

About 0·5m to one metre of cable is needed to connect the controller unit to the first l.e.d., and the l.e.d.s are then spaced at intervals of about 150mm to 250 millimetres. Fig. 4 also provides connection details for the chain of l.e.d.s.

In order to fit an l.e.d., the 3-way ribbon cable must first be split into three separate wires at the point where the l.e.d. is to be fitted/inserted. This is easily done using a modelling knife and a cutting mat, being careful to cut between the wires, and not into them. The wires should be separated over a length of about 20mm.

Wire strippers can then be used to cut through the insulation on each wire, so that it can be pulled apart to reveal a few millimetres of bare wire. This bare wire is "tinned" with solder, and there should then be no difficulty in connecting the l.e.d. to it.

The built-in current limiting of IC3 plus fuse FS1 should avoid disasters if accidental short circuits should occur in the l.e.d. wiring, but it is a good idea to use some Bostik "Blue-Tak" around the leads of each l.e.d. to keep them apart.

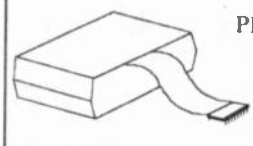
FINAL CHECKS

Give the finished unit a final check before plugging it in and switching on. If all is well the l.e.d.s should provide a psychedelic display as soon as the unit is switched on, and by adjusting the Rate control VR1 it should be possible to control the rate at which the colour change occurs.

If a simple red flashing display is produced, at least one of the l.e.d.s has its "red" and "green" anodes connected the wrong way round. The red sections have a lower turn-on voltage than the green sections, which makes it essential to have all the red sections driven from one output, and all the green sections driven from the other output.

Any attempt at mixed operation results in the red sections limiting the drive voltage to a level that is too low to switch on the green sections. Hence only the red half of each l.e.d. is activated.

Happy Christmas to all *EPE* readers!



Innovations

A roundup of the latest Everyday News from the world of electronics

HOW GREEN IS MY SILICON VALLEY

Not to be outdone by other Celts, Wales is to benefit from the arrival of a Korean electronics giant – *by Hazel Cavendish*

THERE is little doubt that it is the Celtic fringes of the British Isles which are attracting the major inward investment deals in electronics at the present time. Up to now, Scotland has appeared to lead the way, followed by much trumpeting by Eire's Industrial Development Authority that 300 electronic companies employing 34,000 people had been lured to the Republic. However, now Wales is emerging as the UK's leading centre for consumer electronics. One in five British employees in that sector is now employed in Wales.

The Korean electronics giant, the LG Group, announced this summer that it has chosen Newport in Gwent for the location of a £1·7 billion complex which will bring 6,100 jobs to the region and is hailed as Europe's biggest inward investment deal of the decade.

(LG Group was previously known as Lucky Goldstar, but decided earlier this year that its somewhat Western title, redolent of a cowboy riding out from the Last Chance Saloon, could perhaps be replaced by something more dignified.)

THE DRAGON CHALLENGES

Eire based its claim of being "the Silicon Valley of Europe" (so named by John Shepherd, UK and Ireland manager for Gateway 2000) on the figure of 7,200 jobs in the electronics and software industry recorded last year. However, with the LG Group's figure of over 6,000 jobs predicted for their company alone (other electronic interests having already found their way into the Valleys), Wales may be said to be mounting a substantial challenge.

Two separate companies owned by the LG Group will operate from the Welsh site in Imperial Business Park just outside Newport, with an estimated Government grant of around £200 million. The deal was considered a formidable coup on the part of William Hague, Secretary of State for Wales, who was competing with his opposite number, Scottish Secretary Michael Forsyth.

LG Electronics Inc was Korea's first consumer electronics manufacturer in 1958, whose Goldstar consumer electronics now sell in 150 countries and earned £5·6 billion last year, and LG Semicon is one of their major exporters.

DRAM-ATIC INCENTIVE

When fully developed, the factory will produce DRAM (dynamic random access memory) chips, semiconductor wafers, the latest technology available for monitors and TVs, suspension yokes, flyback transformers, and tubes. It will also assemble TVs and monitors at competitive prices. The first phase of the building is expected to be completed in a year's time.

LG said the incentive package offered by the Welsh was the best on offer from any of the European locations it examined, and another decisive factor was the advanced training opportunity available through the long-standing links between the business park and London's Imperial College, and the University of Wales.

The construction of a purpose-built semiconductor training centre swung the decision in favour of Newport, as LG Semicon has set a high priority on R&D, with a target of 8·3 per cent of its revenue to be devoted to this by the year 2,000.

South Wales also benefited from forming part of the M4 Motorway Corridor – the focal point for IT-Electronics related industries in the UK. Welsh consumer electronics now represent 23 per cent of British employment in this sphere.

AND NOW SILICON GLEN

THE above Welsh success story was written prior to the recent news that Scotland is to benefit from investment by the Korean giant Hyundai.

Hyundai Electronics Europe Ltd (HEE) have announced plans to build two microchip manufacturing facilities in Dunfermline. The first phase involves an investment of £1 billion and the creation of 1000 new jobs.

HEE also plans to invest up to £1·4 billion in a second phase which will create a further 1000 new jobs. The plants will produce DRAM chips primarily for the European market.

We now have more than 20 Korean companies manufacturing in Britain and by far the largest share of Korean investment in the European Union.

THE MISSING LINK

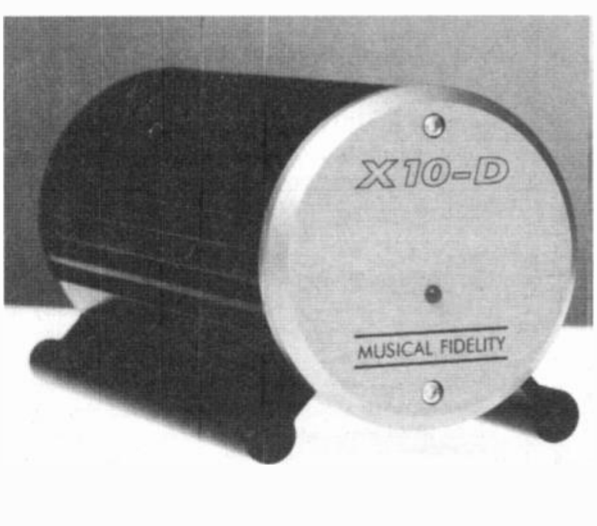
MESSERS Music Fidelity believe that CD players never quite seem to achieve the potential that technical specifications promise. And they believe they know reason why, and how to change all that!

They have found that CD players can be let down by analogue output stages which have difficulties driving variable inductive, capacitive and resistive loads presented by a typical amplifier and cable combination.

To combat these problems, Musical Fidelity have introduced the X10-D system, inventively also known as The Missing Link. What the X10-D does is to offer a perfectly steady load for your CD player's analogue stages to drive. The rest of the system then plugs into the X10-D. Hence, your CD sees a "perfect" load, and you hear a hard-to-believe improvement in sound from your speakers.

It is claimed that the system does not add distortion or noise, and does not alter the frequency response. Rather it turns your existing CD player into a state-of-the-art "sounding" machine!

For further information, contact Musical Fidelity Ltd., Dept. EPE, 15-17 Olympic Trading Estate, Fulton Road, Wembley, Middx HA9 0TF. Tel: 0181 900 2866.



GREATER REALITY THROUGH VR

– By Hazel Cavendish

Widescreen viewing, synchronous smells and faster sound recognition are offering greater credibility to Virtual Reality simulations.

THE USEFULNESS of Virtual Reality is sometimes questioned, largely due to its early appearance in amusement arcades, but its versatility is amply illustrated by recent applications demonstrating steady development in many spheres.

A new widescreen VR system has replaced, in some cases, the headsets which were frequently disliked. Crispin Gray, chief executive of Cadcentre, a software company based in Cambridge, described headsets as "the head-in-a-bucket approach," and his company's Visuality system is based on a Silicon Graphics Onyx computer with three Reality Engine graphics processors, each of which drives a colour projector and generates a third of the display, and can be set up and dismantled in 12 hours.

A 5-metre wide 120-degree wrap-around screen can display an entirely accurate simulation of a building and its setting, although it needs mathematicians to do the complicated calculations for each frame.

One of its uses recently was for a prototype model of an oil-rig to be demonstrated before its construction. The value of this experiment was underlined by a safety engineer's discovery that important safety valves were placed in an inaccessible position, and that the positioning of various ducts posed a potential hazard. This discovery saved the firm £3 million.

Cadcentre are now making the technology available at all visual engineering centres as well as selling complete Visuality systems.

PUNGENTLY REAL

The latest VR development is to produce smells in order to make the viewer feel at home in the environment being presented (*!Ed.*). First in this field was Ferris Productions of the USA, who felt that the fourth sense needed to be added to sight and sound. The viewer is shown to a special chair, where smells are stored in a compressor unit under the seat, with a vaporised droplet being pumped along a small hose to the nose within a millisecond.

In this case, 3D television goggles are still used, presumably with the hose built in. The viewer is treated to seven smells on a fascinating and realistic ride, ranging from the aroma of pine needles and camp-fire smoke to the brine of the seashore.

Now Virtuality, a British VR firm based in Leicester, has developed another olfactory system based on the smell of cordite which can be used with a replica gun with a new "Total Recoil" simulator in a Wild West scene, with all the ingredients for the would-be cowboy. The gas (carbon dioxide) used in the recoil mechanism is also channelled to a valve which mixes it with the smell of a small pinch of cordite delivered to the nasal area of the headset.

NEARLY FIGHTING FIRES

A more practical use of Virtual Reality is being used to train fire-fighters at the Fire Services College in Moreton-in-the-Marsh, Gloucestershire, where a Hampshire firm, Colt Virtual Reality, has developed a low-cost programme using sophisticated technology to enable fire brigades to experience the problems of tackling major incidents such as the King's Cross or Bradford fires. The latest technology allows the company to simulate the reality of a dramatic fire by mirroring the exact conditions at the command and control centre from which such a fire would be fought.

AND SPEAKING OF SAFETY

From defining smells and experiencing the horror of fire, it is logical that someone would move on to research the possibility of recognising exact sounds in order to identify mechanical faults or recognise the nuances of the human voice. A new technology known as Tespar has been developed at Cranfield University and is being marketed by a Shrivenham firm called Domain Dynamics. It is based on mathematics with the object of compactly digitizing the analogue waveforms of sound (and all natural waveforms).

This has previously been done conventionally using Fast Fourrier Transformation (FFT), but the disadvantage is the huge amount of digital data incurred. Cranfield has evolved a system whereby a snippet of sound can be defined completely in only a few bytes of data and can be compared with a stored reference sound "signature".

The technology has wide-ranging applications from monitoring aircraft engines to detect failing components before they cause a crash, to rapidly identifying the voice of a person presenting a credit card.

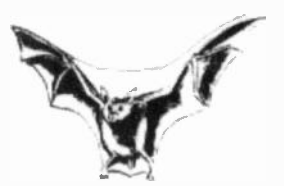
Much interest is being shown by the smart-card firms which propose to base their systems on voice identification. Domain Dynamics have been conducting exhaustive tests and are delighted by the infallibility of the system in identifying a person's voice, even when that person has a bad cold – or is exceedingly drunk!

GET BATTING

RESPONDING to the persistent fascination that people have for trying to find bats, Magenta have introduced their MKII Bat Detector kit, at a mere £27.99 including p&p and VAT.

It had been under consideration ever since Magenta realised the success of the *EPE* original bat detector, in 1989. The new design draws on feedback received from bat enthusiasts all over the UK. It includes many new ideas and provides the following features: 1W audio output; built-in weatherproof microphone; 20kHz to 140kHz range; hand-held case with battery compartment; all-new superhet circuit; compact p.c.b. layout.

Magenta say that assembly is straightforward and should present little difficulty to anyone with basic craft and soldering skills. Apparently, some customers have reported detecting Pipistrelle and Horseshoe bats on the same evening that they have constructed the detector!



As with all their kits, Magenta offer telephone technical support and, if all else fails, for a standard charge will "fix" kits that refuse to work.

For more information, contact Magenta Electronics Ltd., Dept EPE, 135 Hunter Street, Burton-on-Trent, Staffs DE14 2ST. Tel 01283 565435.

PIC-SCANNING SECURITY

SECURE encyption has taken another step forward with the recent launch of a new microcontrolled data coding technique by ScanCard (IPR) Ltd., a south London development company.

ScanCard have recognised that the rapidly growing use of PCs, both in business and private life, for various forms of intercommunication raises the important issue of privacy and confidentiality. It is the Company's opinion that the currently available encryption systems mostly have limitations or drawbacks.

Such systems, for example, might use encryption key codes having up to 500 binary bits. If these codes are the basis of mathematical calculations which need to be made before data can be transmitted, preparation time can be lengthy. Furthermore, such methods may still not guarantee confidentially because computer aided scanning is becoming even more efficient.

The new system developed by ScanCard, which has been patented, has addressed these and other security problems. The microcontroller, a PIC16C84, has been programmed to produce an uninterrupted sequence of binary data giving no clue to the "attacker" where random word lengths begin or end, and thus it is claimed to be impossible to determine which bits are "clear data" and which are "random data".

Additionally, the key codes can be changed at will; error detection is swift and does not require repetition of long blocks of text; authentication elements can be build into the algorithm. ScanCard also say that computer-aided analysis of encrypted data will not reveal how the system works (there's a statement to make any hardened hacker recognise a challenge!).

Also under development by ScanCard is the next version of this system, making it suitable for transmission of data over the telephone. This system is to be the basis of an *EPE* project which we expect to publish in the Spring of 1997.

For more information, contact ScanCard (IPR) Ltd., 250 Brighton Road, Croydon, CR2 6AH. Tel: 0181 688 6067.

WE KNOWS ABOUT WENOS!

AMONGST the information sent through to our Web site is news about the founding of the WeNos Robotics Society. Pronounced "We knows" ('cos they do knows!), WeNos has been formed to further the advances of robotics in general. It is intended that the group should flourish and contribute to the field of robotics, and mobile robots in particular.

There are no monetary dues expected by the group and the only requirement to joining is that you either make contributions to the data base or offer surplus components for general group usage.

If you're interested in robotics (and we know from the survey forms coming back – thanks for them all – that many of you are), you can contact WeNos via E-mail at **The2x4@aol.com**. Who knows, you might even find out how to invent a mobilised version of our forthcoming *Psycho Rat!*

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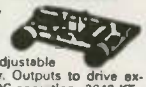

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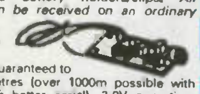
SURVEILLANCE

High performance surveillance kits. Room transmitters supplied with sensitive electret microphones & battery holders/clips. All transmitters can be received on an ordinary VHF FM radio.



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High performance, 2 stage transmitter gives greater stability & high quality reception. 1000m range with 9V battery. 6-12V operation. On/ off switch. Size 70x15mm. *3032-KT. £6.95*

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TRI – Telephone Recording Interface
Connect between phone line & cassette recorder. Automatic-ally switches on tape when phone is used. Records all conversations. Powered from line. 48x32mm. *3033-KT. £6.50*

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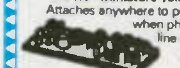
MTTX – Miniature Telephone Transmitter



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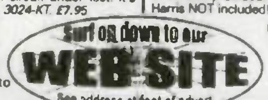

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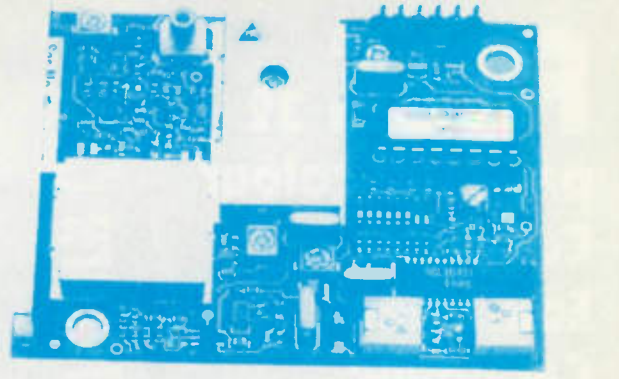

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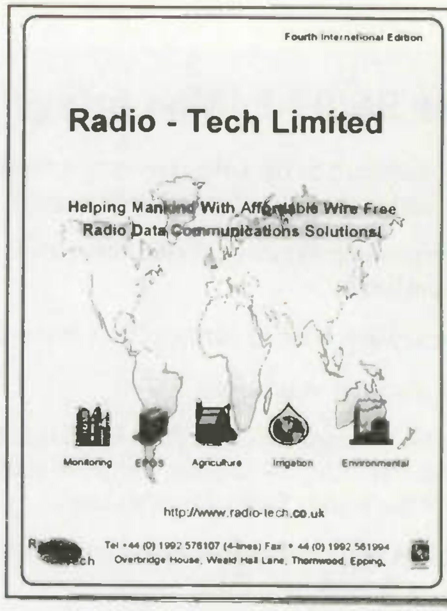

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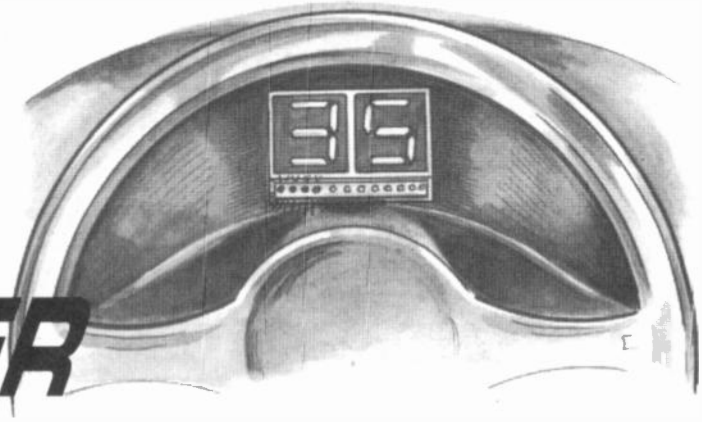
PIC DIGITAL/ ANALOGUE TACHOMETER



HARBANSE DEOGAN

By taking your PIC, you can have the best of both worlds – Digital and Analogue. Reads from 100 r.p.m. up to 9900 r.p.m.

TACHOMETERS are used in a wide variety of fields, e.g. they are found in automobiles to indicate engine speed, in meteorology to measure wind speed from an anemometer, to measure the rotational speeds of lathes and drills, etc. A tachometer will also be used where it is necessary to know if a motor is operating in its specified range or at peak efficiency.

Most tachometers are either digital or analogue, each with its advantages and disadvantages. The digital ones clearly indicate a steady r.p.m., but are not good for indicating trends or where the rotation rate is not steady.

On the other hand, analogue types are excellent for displaying trends but the accuracy of the reading is limited by how accurately you can read the meter scale. Typically the meter movements used in automobiles and motorcycles are heavily damped to give a slow response time, because there is a lot of vibration in these environments and a sensitive, light, highly responsive meter movement would be constantly deflected by the mechanical vibrations giving rise to unsteady readings as the needle judders around the actual reading.

DIGILOGUE

The design presented here combines both digital and analogue displays in a compact, simple design based around a single chip microcontroller, the PIC16C54XT. The digital display is a two-digit seven-segment type which will display the r.p.m. as multiples of 100 up to 9900 r.p.m.

The analogue display consists of two 10-segment bargraph arrays with only 16 elements used. The length of the bar display indicates the r.p.m. The resolution of the bargraph corresponds to 500 r.p.m. per l.e.d.

The benefit of using a bargraph to emulate a meter movement is that it does not suffer interference from vibrations and thus need not be damped. The bargraph can indicate changing r.p.m. with less hesitation than a conventional meter. At the same time the digital display will accurately show steady or slowly changing readings.

OPERATION

A petrol engine works by compressing a fuel/air mixture and igniting it at the right moment to provide power which is transferred to the rotating crankshaft and onto the road wheels via the transmission system. The ignition pulses are produced by a step-up coil which will elevate the 12V it receives to around 15000V necessary to produce a spark in the cylinder.

The timing of the spark is controlled by the distributor and contact breaker – see Fig 1. In modern cars the contact breaker is replaced by a transistorised switch but the basic principle remains the same. The tachometer measures the frequency of the pulses supplied by the contact breaker (which is directly linked to the rotating crankshaft of the engine).

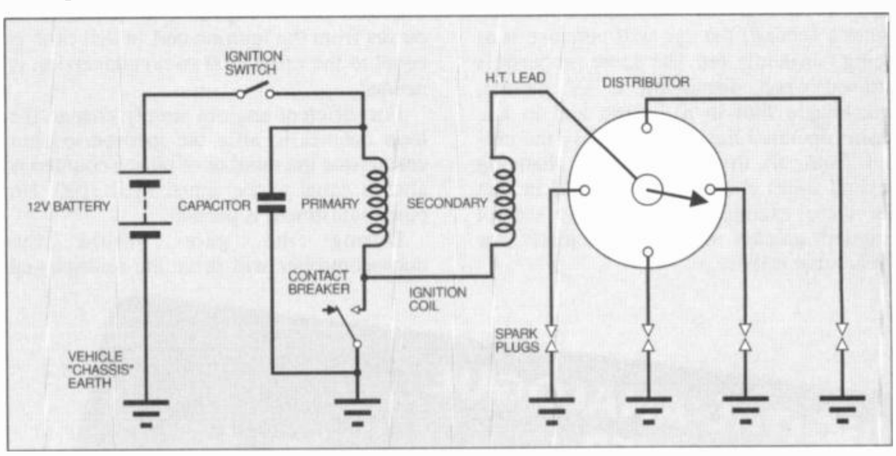


Fig. 1. Conventional set-up for a 4-cylinder vehicle ignition system.

The purpose of this design was to extract the maximum functionality from a minimum component count. This was made possible by the use of a small single chip micro which incorporates on board program memory (ROM), data memory (RAM) and good input/output capability.

The use of a microcontroller to make a tachometer may be likened by some to "using a sledge hammer to break open a nut", but this design will demonstrate how the microcontroller gives the circuit maker a great deal of flexibility in the design – which could not be realised using TTL or CMOS logic devices.

Thus, the tachometer is essentially a frequency counter with the measurement being expressed as r.p.m. (revolutions per minute) instead of Hz (cycles per second). There are basically two ways of measuring frequency:

- Count the number of pulses arriving over a fixed period of time (the gate period).
- Measuring the time elapsed between successive pulses – pulse period – and then calculating the frequency ($f = 1/t$).

The former method is used here as the actual measurement uses less processing

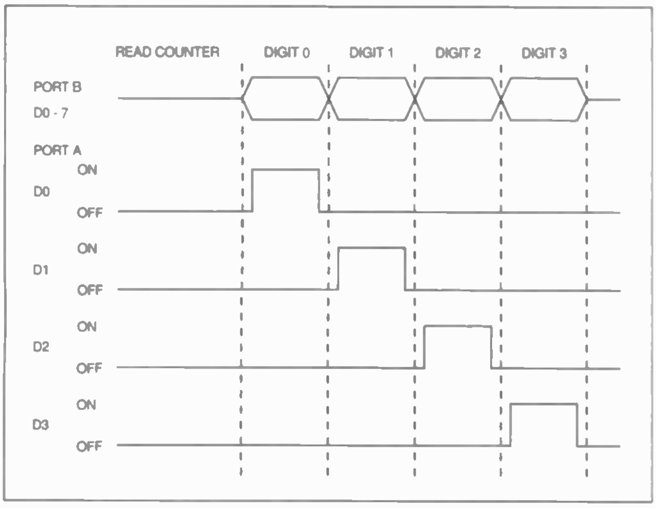
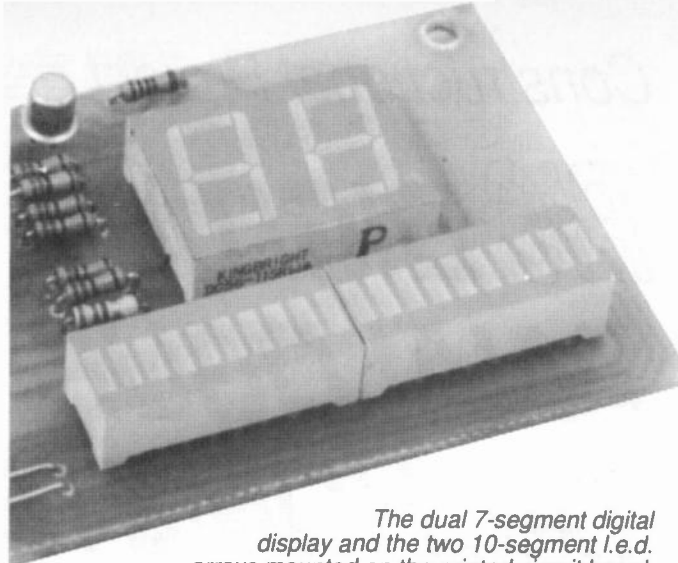


Fig. 2. Multiplex timing sequence.



The dual 7-segment digital display and the two 10-segment l.e.d. arrays mounted on the printed circuit board.

time. The PIC microcontroller has a built-in 8-bit counter which can be clocked directly by an external signal completely independent of what the microcontroller is doing.

When the pre-set gate period has expired the accumulated pulse count in the counter is read, stored and the counter reset ready for the next cycle. The stored values are converted into a form suitable for display (as digital and analogue) and the displays are updated.

DRIVING DISPLAY

The input/output (i/o) capability is not sufficient to drive all the l.e.d.s at the same time – this would require a total of 32 output lines! For this reason the displays are multiplexed as four groups of eight l.e.d.s.

A multiplexed system takes advantage of the property of persistence of vision; if you take a light source and rapidly turn it on and off very quickly (>25 times a second) the eye will perceive it as being constantly on. The same property is utilised when displaying a TV picture, watching a film in a cinema and in a.c. mains operated lighting. In reality the output from all these sources is changing several times a second (25 to 100 in fact for these examples) but the eye cannot respond quickly enough to register the flicker that is there.

As already described, the display of the tachometer consists of four groups (or digits) of eight l.e.d.s. Each digit has power applied for 25 per cent of the time. By rapidly cycling through the digits the eye is fooled into thinking that all the digits are on simultaneously – see Fig 2.

The use of a microcontroller makes the task of multiplexing feasible. Furthermore, it allows one to arbitrarily choose the bit patterns allocated to each digit so that, any combination of l.e.d.s can be lit and also the l.e.d.s can be arbitrarily wired up (in the easiest or tidiest route) and the necessary corrections for the wiring made in software – this is something else that would not be possible if TTL or CMOS logic i.c.s were used.

PROGRAM

The program handles all the timing, counting and display functions. The gate period is set to 300ms for a 4-cylinder 4-stroke petrol engine. The number of pulses from the ignition coil in that time is equal to the r.p.m./100 so no conversion is needed.

For different engines simply change the loop counter to alter the gate period but ensure that the number of pulses counted is always equal to the actual r.p.m./100. No other adjustment is needed.

During the gate period the microcontroller will drive the multiplexed displays. Each display is switched on for around 5ms and a complete cycle takes 20ms. Therefore, the gate period can only be set to a multiple of 20ms.

At the end of each gate period the displays are all turned off and the new pulse count read in from the counter and stored, a value for the bargraph is calculated ready for display, at the same time the counter is reset. All this is done very quickly and does not significantly affect the duty cycle of the displays.

The display multiplexing routine works as follows. Each digit has its own bit pattern specific to the way it is wired up to the microcontroller and whether it is a

COMPONENTS

Resistors

R1	1M	
R2	100Ω	
R3 to R10	220Ω (8 off)	
R11 to R14	1k (4 off)	

All 0·25W 5% carbon film

See SHOP TALK Page

Capacitors

C1, C2	22p disc ceramic (2 off)
C3	100µ radial elect. 16V
C4	100n polyester
C5	100p polystyrene (see text)

Semiconductors

D1, D2	1N4002 1A 100V rect. diode (2 off)
TR1 to TR4	BC108 *npn* silicon transistor (4 off)
IC1	PIC16C54XT microcontroller (pre-programmed – see text)
IC2	LP2950 5V low-power voltage regulator
X1/X2	dual 0·56in. 7-segment l.e.d. display, common cathode
X3, X4	10-segment l.e.d. array (2 off)
X5	4MHz crystal

Miscellaneous

Printed circuit board available from *EPE PCB Service*, code 127; plastic ABS case, size 111mm x 57mm x 22mm; 18-pin d.i.l. socket; small piece of red filter for l.e.d. displays; auto-type connecting wire; solder pins; solder etc.

Approx Cost Guidance Only £35

7-segment display or a bargraph array. The 8-bit port B is used to drive the segments while the 4-bit port A is used to control the digit drivers (buffered through the transistors).

Initially, all the segment drivers are off, the bit pattern for the first digit is output to port B and then the first digit driver is switched on. This lights up the first display.

After 5ms the digit driver is turned off, the bit pattern for the second digit is output to port B and then the second digit driver is switched on. This procedure is repeated for both digits and both bargraphs, at any given instant only one of them is lit but to the eye it appears as if they are all on – thanks to persistence of vision.

CIRCUIT DESCRIPTION

The full circuit diagram for the Digital/Analogue Tachometer is shown in Fig. 3. The power supply regulator (IC2) circuit is also included.

The microcontroller, IC1, which forms the heart of the Tachometer is Arizona Microchip's PIC16C54XT, an 18-pin device. It has 12 input/output (i/o) pins (made up of a 4-bit port and an 8-bit port) with high current capability (about 20mA), 0·5K of program memory, 32 bytes of data memory, an 8-bit counter, an 8-bit prescaler and a watchdog timer. It is more or less a stand-alone device requiring a minimal support circuitry.

A 4MHz crystal X5 is used to drive the clock and since this determines the accuracy and stability of all the timing functions it is this factor that determines how accurate the Tachometer will be. By knowing the clock frequency beforehand, the program can be written in such a way that the Tacho does not need to be calibrated before use.

The 8-bit port (pins 6 to 13) is used to drive the segment l.e.d.s of each digit directly through current limiting resistors R3 to R10, but the digit drivers are buffered by transistors TR1 to TR4 because the total current drawn, when all eight l.e.d.s are on, will exceed the current capability of a single pin.

PULSE COUNTING

The pulse counting and display driving functions are all handled by the PIC (IC1). The input circuit is designed to give good sensitivity while providing adequate protection against overloading and reverse voltages.

The input port for the 8-bit counter (pin 3) has a high impedance so that it will not significantly load the signal source. A high value series resistor (R1) limits the current that can flow into the pin. A diode (D1) is used to shunt away high voltage positive going spikes to the supply line and the microcontroller has a built in clamping diode to safely dissipate any negative going spikes. Since the supply has a very low impedance it will absorb these signals without unduly affecting circuit operation.

This microcontroller input has a Schmitt trigger to help with noise immunity, however, capacitor C5 has been introduced to help in suppressing any high frequency "ringing" produced when the vehicle contact breaker points (or switch) open. The precise value of C5 is not important and the optimum value may vary from vehicle to vehicle. It should be large enough to absorb any unwanted signals but small enough to allow the ignition pulses through.

It may be necessary to experiment to find the most suitable value for any particular case. From the circuit it is clear that the capacitor is functioning as a low-pass filter in conjunction with the input resistor R1. If the resistor value is changed then it may be necessary to change the capacitor value too.

The bargraph (X3 and X4) consists of two cascaded 10 l.e.d. arrays and of these only 16 l.e.d.s are actually used. The 16 l.e.d.s light up in sequence as the r.p.m. increases, the size of the "bar" being proportional to the r.p.m..

The l.e.d. arrays can be replaced with individual l.e.d.s so that as the r.p.m. approaches a dangerously high level the colour of the bargraph changes. A suitable choice would be green for OK, orange or yellow when approaching a dangerous level and red for danger level.

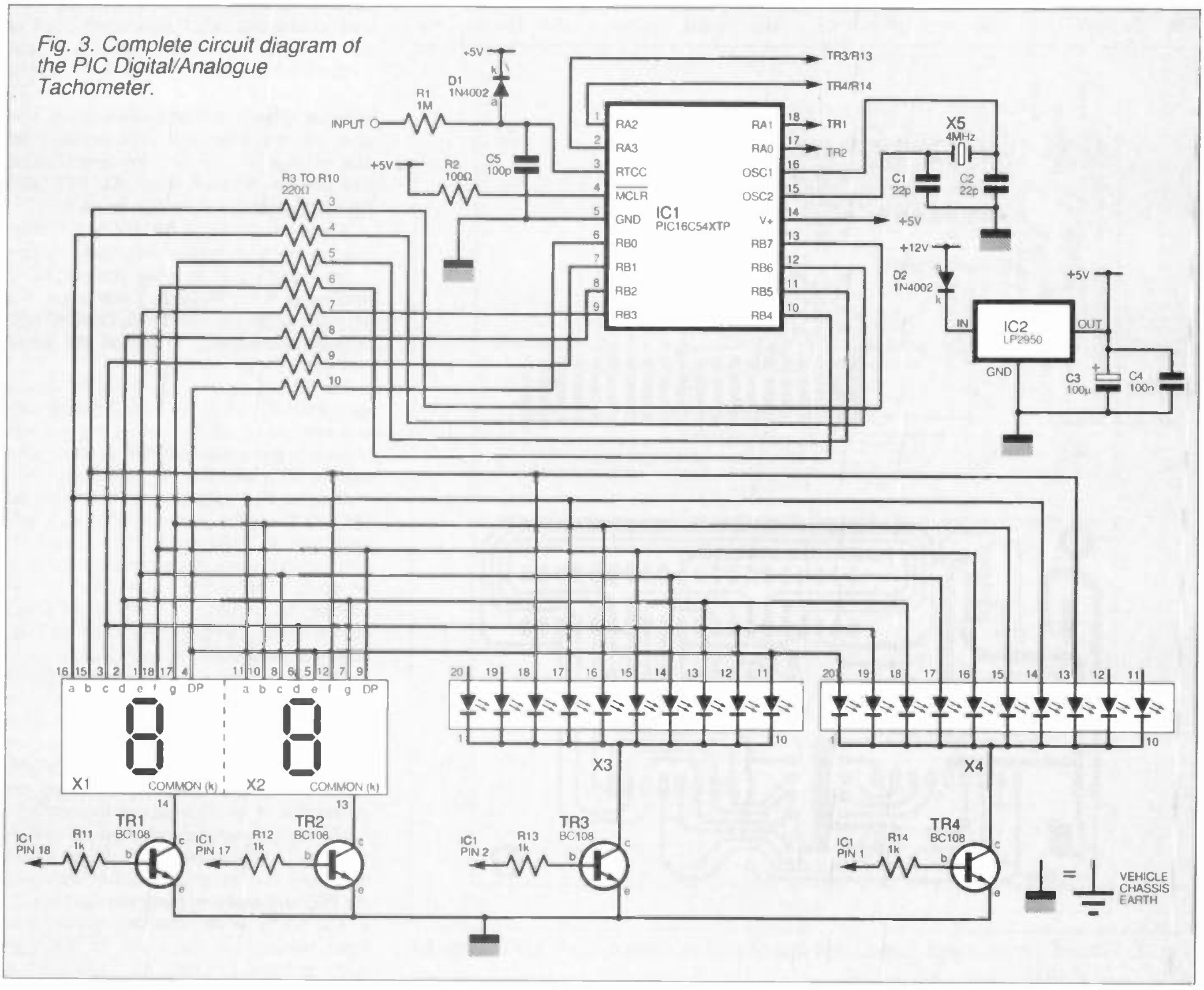


Fig. 3. Complete circuit diagram of the PIC Digital/Analogue Tachometer.

POWER SUPPLY REGULATION

The LP2950, IC2, is a low power voltage regulator that can handle input voltages of up to 30V. A reverse protection polarity diode D2 is provided to protect against wrong connections and reverse voltage transients.

Although specified as operating at 12V a car's electrical system often sees very large variations in the supply voltage even if very briefly. When a car is being started the voltage available can fall to as low as 6V as the starter motor turns over. Once started the alternator is the main source of electric current and the available voltage will typically be about 14V. Switching off the ignition produces "field transient decays" which can cause the voltage to "shoot up" to − 100V for a 100μs or so.

This should give you an idea of how hostile the cars electrical system can be and how an unprotected voltage regulator could be easily destroyed.

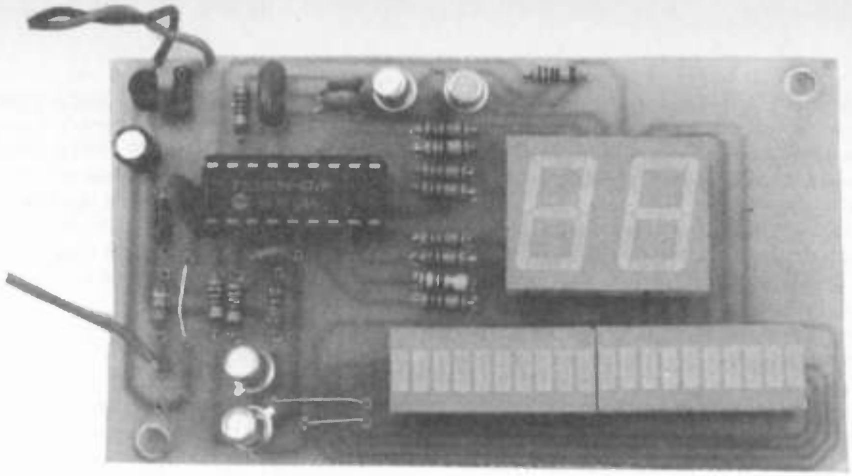
CONSTRUCTION

With the small number of components used, the Digital/Analogue Tachometer can be built quite easily on a small single-sided printed circuit board (p.c.b.). The topside component layout and full size copper foil master pattern are shown in Fig. 4. This board is available from the *EPE PCB Service*, code 127.

The microcontroller should be mounted in a socket since it is a static-sensitive part. The displays are also semiconductor devices and therefore susceptible to electrostatic and heat damage; however, they are generally quite robust and will survive soldering as long as the technique used is good. Besides, using i.c. sockets for the displays will give these parts a very high profile on the board.

The segment driver resistors have been chosen with standard power l.e.d.s in mind. If you plan to use low power types then the value of these resistors should be increased accordingly. Note that you *cannot* mix standard and low power l.e.d.s in this circuit since they will be sharing the same segment driver resistors. For a bright display it is recommended that you use high efficiency l.e.d.s (sometimes referred to as "super red").

The bargraph is made up of two × 10 l.e.d. arrays in order to make installation easier and because they usually cost less than buying discrete l.e.d.s. The spacing between the anode (a) and cathode (k) pins gave sufficient space for routing tracks on the p.c.b.



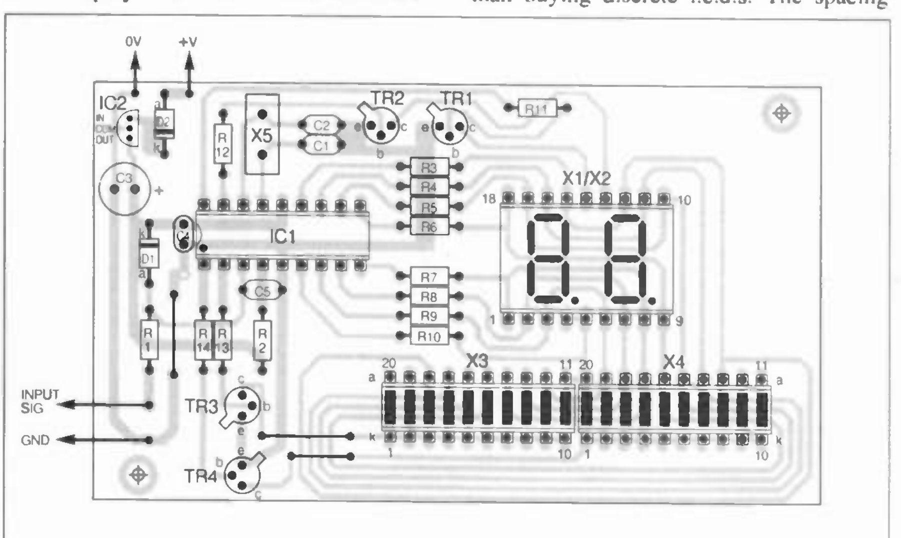


Fig. 4. Printed circuit board component layout and full size copper foil master for the PIC Digital/Analogue Tachometer.

Before you start construction make sure that all the surfaces to be soldered are clean and free of any grease, that includes the component wires as well as the board. Begin the assembly with the three wire links first and then install the resistors and the diode followed by the capacitors.

Next come the transistors and voltage regulator IC2, ensure that they do not protrude too high off the board so that they will fit in the chosen box. The i.c. socket can be fitted next followed by the dual 7-segment display and l.e.d. arrays.

SOFTWARE

Before the PIC16C54XT microcontroller can be asked to "perform" its duties, it needs to be programmed. A software 3·5in disk containing the source-code and a Hex file for the PIC Digital/Analogue Tachometer is available from the Editorial Office for the sum of £2·50 UK, £3·10 overseas surface mail or £4·10 airmail. This is to cover admin costs and postage, the disk is *free*. It can also be down-loaded *free* on the Internet from our FTP site: **ftp://ftp.epemag.wimborne.co.uk**.

A pre-programmed PIC16C54XT chip, (set up for a 4-stroke, 4-cylinder engine – see later) ready to plug straight in, is obtainable from Magenta Electronics. See *Shoptalk* page for details. A detailed description and listing is beyond the scope and space for this article.

The listing supplied on the *EPE* disk is for a PIC16C54XT. The configuration code will need to be set by you as it is not embedded in the source file. Set the configuration for XT, protection ON, watchdog ON.

Another PIC microcontroller besides the 16C54XT can be used as long as it will work with a 4MHz crystal. The source file will require some minor modifications to be made. The listing shows the changes needed to program a 16C84XT (this device uses EEPROM and so can be reprogrammed over and over again).

Do not use parts with the suffix ***RC*** as these are designed to be used with a resistor and capacitor in place of the crystal as a clock source and the clock frequency then generated is not stable or predictable necessitating the need for checking the calibration of the Tachometer frequently.

Having programmed or obtained a ready "blown" microcontroller, double-check the board over once again before installing the PIC and applying power to the circuit.

The walls of the specified plastic case taper inwards so the width of the case starts at approx. 53mm and then reduces gradually. Ideally, the p.c.b. should be 52·7mm wide to fit snugly inside this case, so it isn't absolutely necessary to use the mounting holes if you don't want to – but it is recommended, otherwise the p.c.b. may work loose in time.

NOTE: There can be some variation in the manufacturing process, and if the p.c.b. is too wide for the case try inserting it at a slight angle and then using the mounting holes to hold it in place.

The infra-red l.e.d. filter sheet can be glued to the outside of the case (glossy side down) in order to cover the cutouts for the bargraphs neatly and the whole project smartened up with some white graphics transfer text.

TESTING

Commence testing by apply about 12V to the p.c.b., the exact value is not important and a battery or unregulated supply will do as a temporary power source. The digital display should light and display 0 with the leading zero blanked, the bargraph should not be lit.

Now touch the input with your finger to feed a "50Hz mains hum" signal to the Tachometer. The display should now change to "15" and three l.e.d.s of the bargraph should light up. The 15 represents 1500r.p.m.

On a 4-stroke, 4-cylinder petrol engine (as found in most cars) the ignition coil will produce a frequency of 50Hz when the engine is turning at 1500 r.p.m.. If the engine you wish to fit the Tachometer to happens to have a different number of cylinders then you will need to change a number in the program to change the gate time. See Table 1 for details.

To thoroughly test the circuit board get hold of a Signal Generator, which can output between 10Hz and 350Hz. Connect it to the Tachometer input and slowly sweep up the frequency range at the same time checking the displays. The bargraph should increase in length steadily and the digital display should count up steadily.

As the display steps past "99" it should change to show "--" which is an over-range indication and the bargraph should remain fully lit.

INSTALLATION

Having verified that the unit is working properly it is time to install it in the car.

Locate the ignition coil and identify the wires coming from it. The large thick wire at the very top of the coil is the HT lead which goes to the distributor and on to the spark plugs. Either side of this are two thinner wires, one of which goes to the +12V supply and the other to the contact breaker, *it is this side* (which may also be labelled CB-) from which the tachometer signal is picked up.

To make the connection from the Tachometer to the CB- side of the coil use

Table 1: Constants for Gate Periods

HEX	DEC	period/ms	Applications
30	48	150	4 pulses/revolution, e.g. 8 cylinder 4 stroke engines
40	64	200	3 pulses/revolution, e.g. 6 cylinder 4 stroke engines
60	96	300	2 pulses/revolution, e.g. 4 cylinder 4 stroke engines engines
C0	192	600	1 pulse/revolution e.g. single cylinder two stroke engines

a "lucar" spade connector (tap splice) or a "snap-lock" type which will let you tap into the wire without cutting it. Once the Tachometer pickup has been connected, carefully route it back to the passenger compartment in such a way that it does not come close to any leads that will carry high voltages or heavy currents or anything hot such as the engine.

The power supply for the Tachometer will have to be taken from a suitable point in the wiring harness. It is not possible to give specific details for this as the wiring varies so much from manufacturer to manufacturer. As a general guide find a point where +12V is present only when the ignition is *on*, thereby ensuring that when the engine is off so is the tachometer.

Ensure that there is a fuse between the 12V battery and the Digital/Analogue Tacho, if there is any doubt fit an in-line fuse. The 0V line (or chassis) can be connected to any good "ground" point on a *negative earth system.*

CASE DETAILS

If you choose the specified case then refer to Fig. 5 for the position and sizes of the cutouts. There are three apertures to be made: for the dual 7-segment display, the bargraphs and the entry/exit point for the wires.

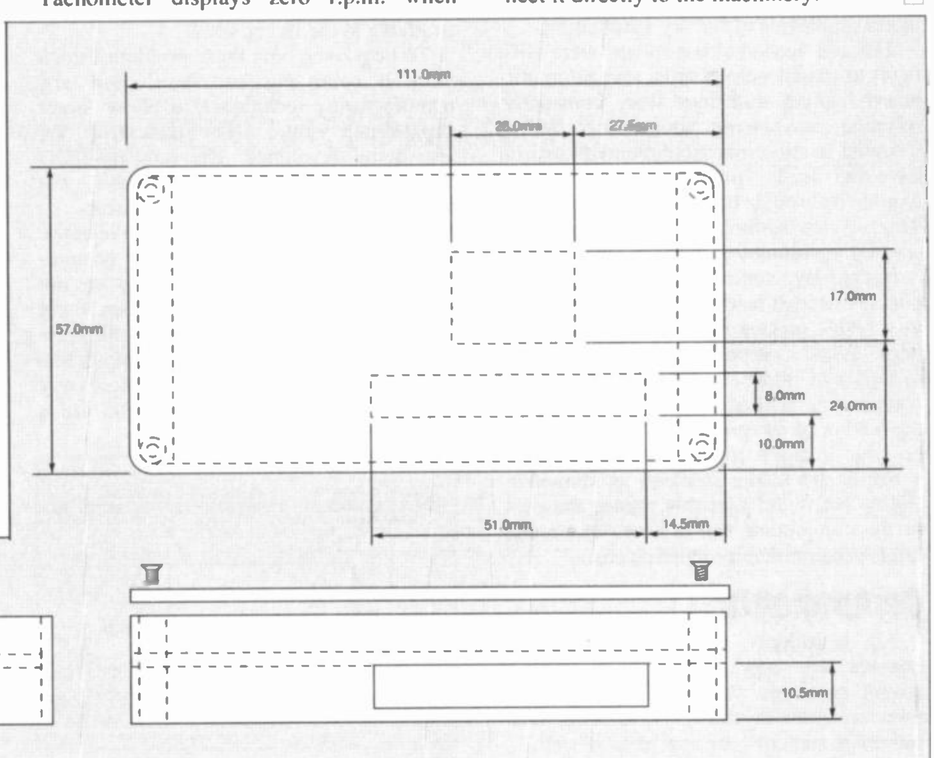
APPLICATIONS

As it stands, the PIC Digital/Analogue Tachometer displays zero r.p.m. when there is no input, and none of the bargraph l.e.d.s light up. When the input reaches 500r.p.m. the first l.e.d. will light.

Some people may prefer to have an l.e.d. lit even when the r.p.m. is zero, and another l.e.d. lighting when 500r.p.m. is reached. To do this simply connect a low value resistor (about 200 to 500ohms) between the +5V supply and the anode (a) of the l.e.d. in the bargraph preceding the one which lights up at 500r.p.m.

The envisaged application for the Tacho is as a rev-counter for petrol engined cars. With a little imagination its uses can be extended. For example, it could be used on motorcycles or boats as a rev-counter and diesel engines can be accommodated by placing a suitable sensor in front of the Tacho, such as one that can detect the vibrations from the fuel injectors. Interfacing the Tachometer to a Hall-effect sensor will permit its use with anemometers that rotate a magnet.

A non-contact Tachometer can be constructed by using a phototransistor at the input to pickup a beam of reflected light from a rotating shaft with a dab of white paint or a small piece of reflective tape paced on the shaft. The light source will need to be modulated and a high-pass filter incorporated into the receiver to provide rejection of ambient light. This form of tachometer can be used in the workshop to measure the rotational speeds of drills, lathes, motors, etc. without having to connect it directly to the machinery.



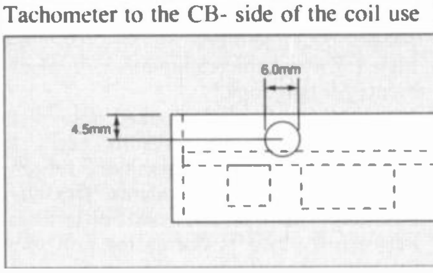


Fig. 5. Case dimensions and drilling details.

New Technology Update

It is not just their size that has enabled "surface mount" components to grab up to 80 per cent of the p.c.b. manufacturing market – reports Ian Poole.

IT IS claimed that surface mount technology (s.m.t.) is now firmly established, and that most new electronic products which are launched onto the market these days use it. Currently it is estimated that over 80 per cent of boards manufactured use the technology, showing the extent of its use.

Surface mount technology has caught on very quickly. It was only six or seven years ago that many areas of the electronics industry thought of s.m.t. as a specialist technique. Now this could not be further from the truth.

The reasons for this rapid growth are two-fold. First of all, many products could simply not be made without its use. Modern laptop and palmtop computers would be much larger than those widely available on the market today.

Mobile phone technology has also forced the market along this road. It is only necessary to think back a few years to the phones which were available then. Today's phones can slip into a top pocket, and they are less than a quarter the size of their predecessors.

But size is not the only factor which has lead to the success of s.m.t.. Virtually all of today's larger electronic consumer goods like televisions, videos and hi-fi units use it. The reason for this is not primarily size, but the reduction in manufacturing costs which s.m.t. brings. The technology was designed to meet ever increasing levels of factory automation.

The old leaded components were difficult to mount onto boards, and automatic board loading machines were constantly stopping, or placing components badly. Coupled to this, many components had to have their leads "preformed" so that they would fit through the holes in the boards. This was an additional process which increased manufacturing costs.

Eventually, someone asked why components needed leads in the first place and as a result surface mount technology was born. When components were connected to tags and pillars in the days of valves, components needed leads. However, with the advent of the printed circuit board it is possible to lay a component directly onto a board and solder it down as shown in Fig. 1. Not only does this reduce the cost of the component, but it saves space and reduces equipment production costs.

Components

All commonly used types of components are now available in surface mount packages. Also, many less common components like crystals, and even inductors and coils are available as well.

In fact, some new integrated circuits are not being manufactured in the traditional through hole mounting packages. The reason for this is that there is not sufficient volume to warrant marketing them in these packages.

The first components to be made widely available were resistors and capacitors. These come as small blocks or chips. They come in a variety of sizes and 1206 packages (measuring 3·2mm × 1·6mm) were the first. These have now been superseded by 0805 (measuring 2·0mm × 1·25mm) and now 0603 (1·6mm × 0·8mm) are being used in many new designs.

For the future even smaller packages will be used. The next in line is the 0402 (1·0mm × 0·5mm). Although resistors are available in this package now, and some Japanese companies are using them, it is not envisaged that they will be greatly used in Europe until the turn of the century.

Capacitors

Capacitors are also following similar size reductions. The highest usage is in the 0805 package, but many people are turning to the 0603 size.

The problem with using ever smaller capacitors is that it becomes increasingly difficult to fit the required value of capacitance into these minute packages. Working voltages or capacitance values which are available in these smaller packages are often less than those available in the larger sizes.

To help overcome these problems much work is being put into developing new manufacturing techniques to allow larger capacitance values. New dielectrics are also being developed. The standard COG and X7R dielectrics are available, but others, including Z5V, are being used.

Often the problem with the dielectric which has to be used for higher voltages and capacitance values is that they are not particularly stable, and this makes them unsuitable for any applications which are capacitance sensitive. For applications like tuning and for filters it may be necessary to adopt a larger package size and use a better dielectric.

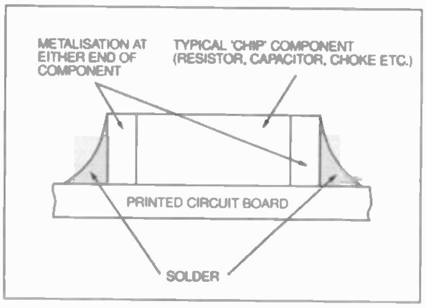


Fig. 1. An s.m.t. component soldered to a board.

One of the advantages of using the smaller packages can be an increase in reliability.

Unlike leaded components where there is a large degree of flexibility in the leads, this is not so with surface mount boards. This means that flexing of the board can cause problems. Although this does not normally occur when the board is mounted in a piece of equipment, the temperature changes during processes like soldering can bring about movement and set up stresses which can lead to cracking and failure of the component.

Capacitors are the most prone to this, although it is much improved when smaller packages are used. Larger sized components experience much greater degrees of bending as a result of the geometry, and fail more frequently. Although this may appear to be a major problem, only a small fraction of components fail in this way and most manufacturers have the situation under control.

Higher Values

Electrolytic capacitors are widely used where values in excess of a microfarad (1µF) or so are needed. Sometimes, where space is at a premium, tantalum capacitors are employed.

However, electrolytic capacitors cannot undergo the soldering processes which are required for surface mount technology. If they are to be used, they have to be added on afterwards, usually by hand, and this is most conveniently achieved if they are leaded devices.

Tantalum capacitors are the other alternative, and vast quantities of them are used. Their drawbacks are cost and availability. Even the leaded tantalum devices are significantly more expensive than their electrolytic counterparts. In a very competitive market, where equipment manufacturers are looking to reduce costs wherever possible, this means that other alternatives are always being investigated.

One of the methods of overcoming this is to use a high value ceramic capacitor. Nowadays, a number of component manufacturers are offering these high value ceramic capacitors as replacements for tantalum.

Sometimes they are looked upon with some scepticism, but results seem to indicate they are possibly more reliable than their tantalum equivalents. The other advantage is that the cost differential between the two is decreasing and soon the high value ceramic capacitors may be cheaper than tantalum.

Is your PCB design package not quite as "professional" as you thought? Substantial trade-in discounts still available.

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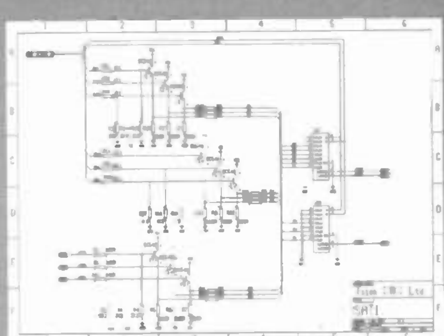

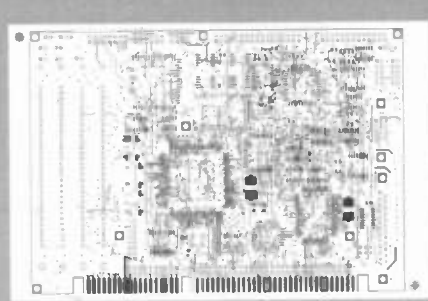

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- All the features of BoardMaker1
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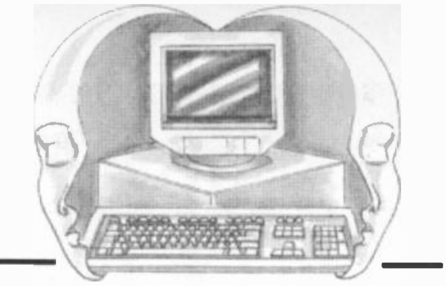
INTERFACE



Robert Penfold

CODED SERIAL INTERFACING

ONE OR TWO readers have suggested that the various serial encoder and decoder chips that are now available might offer a simple means of connecting a computer to a robot, "buggy", or other remote controlled device.

Parallel interfacing is far from ideal for this type of thing for two reasons. One reason is simply that a multi-way connecting cable is needed, and this tends to be rather cumbersome, particularly when controlling something that is mobile or even semi-mobile.

The other is that parallel interfacing tends to give a rather limited operating range. Connecting cables more than about two metres long can be troublesome, with data being corrupted due to signals being coupled from one data line to the next.

Code Cracking

Serial interfacing is usually the more practical approach, as it generally requires just two or three connecting wires. Even with high baud rates it is possible to use cables many metres long. Serial interfacing using UARTs, such as the industry standard 6402, has been covered in previous *Interface* articles.

These offer a reasonably simple but effective solution to serial interfacing, but they are sometimes less than ideal. UARTs are relatively expensive, and their 40-pin d.i.l. encapsulations can be difficult to accommodate if the available space is strictly limited.

Although serial encoder and decoder chips, such as the popular HT12 series, may seem to offer a cheaper and smaller alternative, things are not quite so rosy on closer examination. These chips are primarily intended for use in remote control systems. In particular, they are intended for use in things like car security systems that are switched on and off via a u.h.f. radio link.

The problem in using a radio link in this application is that there is only one channel available. Therefore, the system has to include a method of encoding and decoding that prevents each transmitter operating every receiver in the vicinity.

This is done by sending and decoding a binary code, which in the case of the HT12 series is 12 bits long, giving 1024 possible code numbers. The decoder only responds to the signal from the transmitter if it contains the correct 12 bit code.

Pinouts

Pinout details for the three devices in the HT12 series are shown in Fig. 1. The only encoder chip is the HT12E. The 12-bit binary code is set up on address inputs A0 to A11, and it is transmitted in serial form on the output terminal (pin 17) for as long as the transmit enable input (pin 14) is held low.

The HT12F is the simpler of the two decoder chips. The 12-bit binary code is set up on its address inputs, and provided this code matches the one from the transmitter, its VT (valid transmission) output at pin 17 goes high.

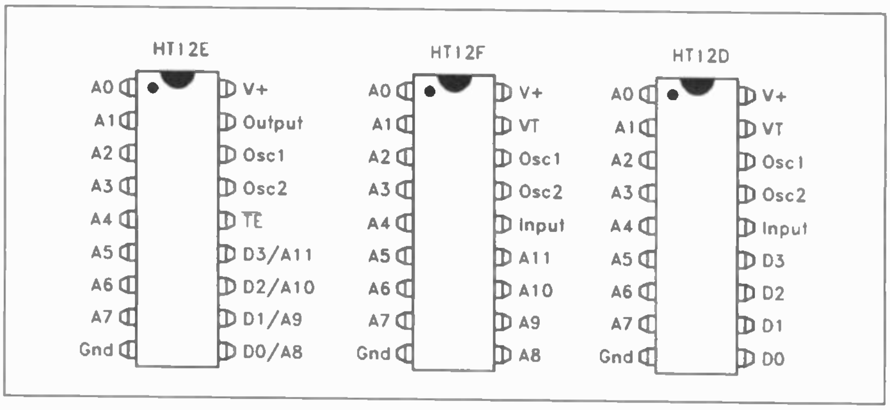


Fig. 1. Pinout details for the HT12 series of serial chips.

Unfortunately, there is no easy way of sending 12 bits of data via these two chips. It would be possible to cycle through all the possible 12-bit addresses until the VT output went high. The binary code on the inputs of the receiver would then match that at the transmitter. However, with some 1024 possible codes, this would be a rather slow and impractical way of handling things.

The alternative decoder chip is the HT12D, and this is more useful in a computer interfacing application. This is used in much the same way as the HT12F, but it treats the received 12-bit codes rather differently.

Only the eight least significant address inputs are checked against the received binary codes. If these match the code in a received signal, the four most significant bits in the received number are treated as data, and placed on the four data outputs (D0 to D3). Address inputs A8 to A11 on the HT12E encoder chip then effectively become four data inputs.

Exchanging Nibbles

A combination of the HT12E and the HT12D therefore provides a simple means of exchanging binary data, but only in the form of 4-bit nibbles rather than 8-bit bytes. The circuit diagram for a basic serial link based on these two chips is shown in Fig.2.

Both the HT12E and the HT12D have built-in clock oscillators that require only one discrete component. This is a resistor that sets the clock frequency. Note that the transmitter operates at a much lower clock frequency than the receiver, and that R1 is correctly shown as having a much higher value than R2. The actual clock frequencies are about 3kHz for IC1 and 150kHz for IC2.

I do not have any information about the internal workings of either chip, but the method of encoding and decoding seems to be fairly sophisticated because the system works reliably without any accurate matching of the two clock frequencies.

In Fig. 2 the transmitter and receiver are shown working from the same five volt supply, with three wires connecting the transmitter and receiver circuits.

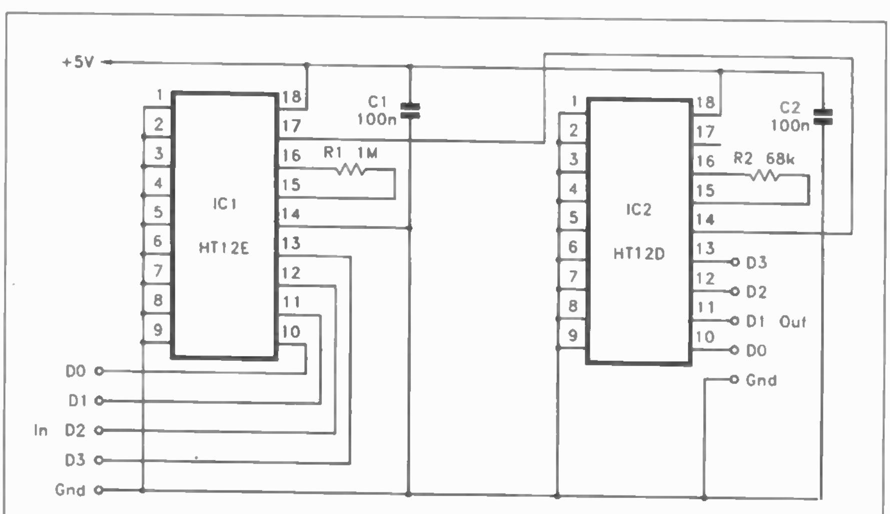


Fig. 2. Circuit diagram for a basic 4-bit link.

Of course, the system will work equally well if the two circuits are powered from separate supplies, and a pair of connecting wires are used.

Remember that this is a serial system, and that there will be a delay of a few milliseconds between fresh data being placed on the inputs, and the outputs responding to the changes. The current consumption of the circuit is very low, and is typically about 400 microamps each for the transmitter and receiver.

Exchanging Bytes

It is actually quite simple to use the HT12 chips to transfer full 8-bit bytes of data, and it is basically just a matter of using an extra HT12D at the receiver. One chip handles the most significant nibble, and the other deals with the least significant nibble. The circuit for an 8-bit serial system is shown in Fig. 3.

Output D5 is used to control one of the address inputs (A7) of IC1. This enables data to be directed to one or other of the decoder chips in the receiver circuit.

Setting D5 low results in data being sent to IC2 (the least significant nibble), and setting it high results in data being sent to IC3 (the most significant nibble). There is no need to add data latches at the outputs of IC2 and IC3, because the HT12D has built-in data latching. Once the outputs are set at a certain binary pattern, they retain that pattern until fresh data is received.

Sending a byte of data is rather convoluted, but it should not be too difficult to work out a routine that produces the desired effect. This is the basic sequence of events:

1. Start with D5 low and D4 high (send a value of 16 to the interface).
2. Bitwise AND the number to be transmitted with a value of 15 to remove the most significant nibble.
3. Write this value to D0 to D3, and then pulse D4 low. For example, if a value of 5 is to be sent, first 5 would be written to the interface. This results in the data being sent to IC2. Then a value of 21 would be written to the output port, which sets D4 high, halts transmission, and latches the data into IC2.
4. Bitwise AND the 8-bit value with 240 to remove the least significant nibble. Divide this value by 16, add 48 to it (to set D5 high and keep D4 high), and write the value to the output port.
5. Pulse D4 low to send the data to IC3 and latch it, while keeping D5 set high. For example, suppose that the value to be written to IC3 is 11. The value already written to the port is 59 ($11+48=59$). Writing a value of 43 ($59-16=43$) sets D4 low and sends the data, and a value of 59 sets D4 high again so that transmission ceases and the data is latched into IC3.

Remember that a serial interface is rather slow by normal computer standards. A very brief pulse to D4 might not give reliable results, and it is advisable to use a delay loop to extend this pulse to at least a few milliseconds.

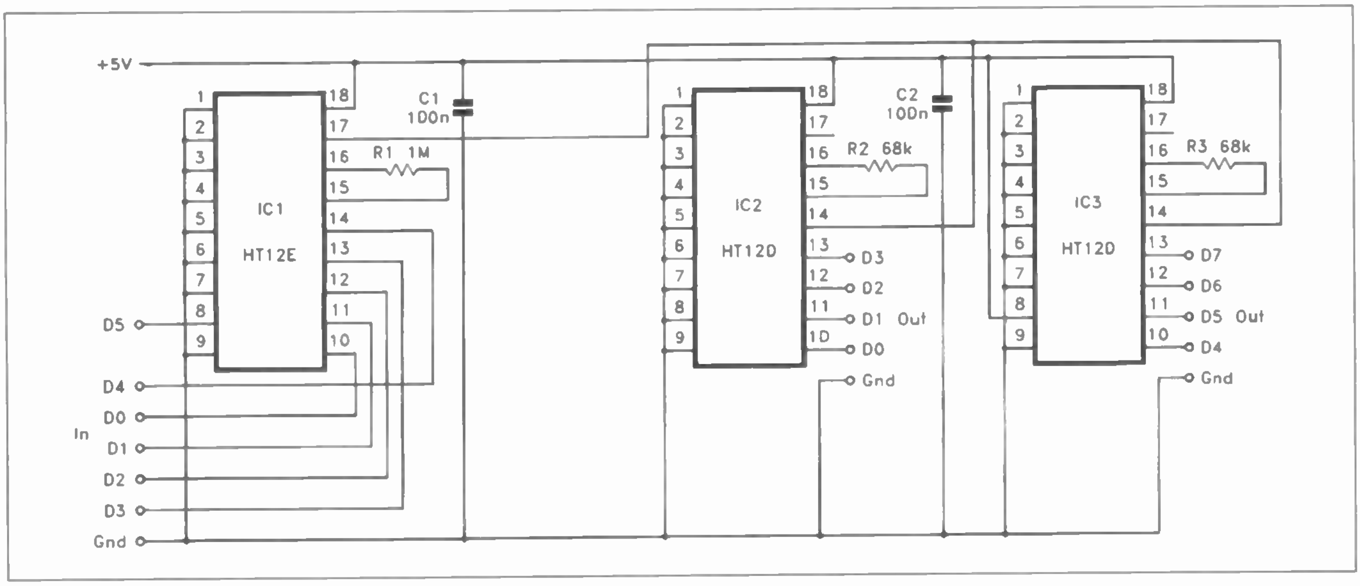


Fig. 3. Circuit diagram for the 8-bit serial link.

For this system to work properly, it is necessary to utilize a couple of additional outputs from the computer to control the flow of data. This should not be a problem in practice, since the system still only requires six outputs to transfer eight bits of data. Data output D4 is used to control the "transmit enable" input (pin 14) of IC1, and it is briefly pulsed low in order to produce a burst of transmission on the serial output.

In theory it is possible to use the output port to control more address inputs of IC1 so that further HT12Ds can be added to the receiver circuit. Each additional address line should enable an extra pair of HT12Ds to be used. I have not actually tried this, and the software side of things would become even more convoluted, but it should be possible to obtain 24 outputs from an 8-bit output port.

BUILD YOUR OWN PROJECTS

Alan Winstanley

Part 2

IN THIS series of articles which will be presented over the next few months, we shall be describing modern methods for constructing your electronic projects. This second part offers some initial tips for beginners and discusses assembly techniques, including soldering.

Future parts will look at case and enclosure preparation, workshop tips and tricks – in fact, everything you need to know to get satisfying results when building your latest *EPE* project!

Alan is, of course, Surgeon-in-Chief at *Circuit Surgery*, and enjoys all aspects of electronics.

LAST MONTH, Build Your Own Projects introduced some of the basic hand tools and test equipment which are used when constructing electronic circuits. Not all of the items discussed are essential though there are some which you will find indispensable.

Gradually, as you gain more experience and your interest develops, you might wish to invest in more refined or better quality tools and equipment, as well as purchasing the occasional luxury item which will help simplify construction, maybe saving you some elbow grease or helping you to improve the finished quality of your work.

We now look at the task of circuit board assembly, and most importantly, the art of soldering electronic components. To start with, let's consider some of the various techniques for assembling electronic circuits, whether during prototyping or with a final, permanent construction in mind.

PROTOTYPING METHODS

First, *solderless breadboards* are extremely useful for plugging simple circuits together quite quickly: they're the simplest form of "test-bed" and can be instantly modified as necessary.

Breadboards consist of rows of spring contacts, into which component leads are carefully pushed. The contacts form wipers which generally make an effective electrical connection with the components, and insulated wires are used to interconnect rows and terminals as necessary.

They are ideal for younger students too, since no soldering is necessary, and they can be used for starting the development of simple transistor and integrated circuit (i.c.) projects successfully. Products such as the *EuroBreadBoard* are always handy for quick experiments with a handful of components.

However, prolonged use of the contacts by repeatedly inserting leads can weaken their ability to make proper connections. In such cases it can be extremely frustrating to find out why a breadboarded circuit fails to operate correctly – is the circuit concept genuinely faulty, are the components in the right holes, or are the contact connections simply not satisfactory?

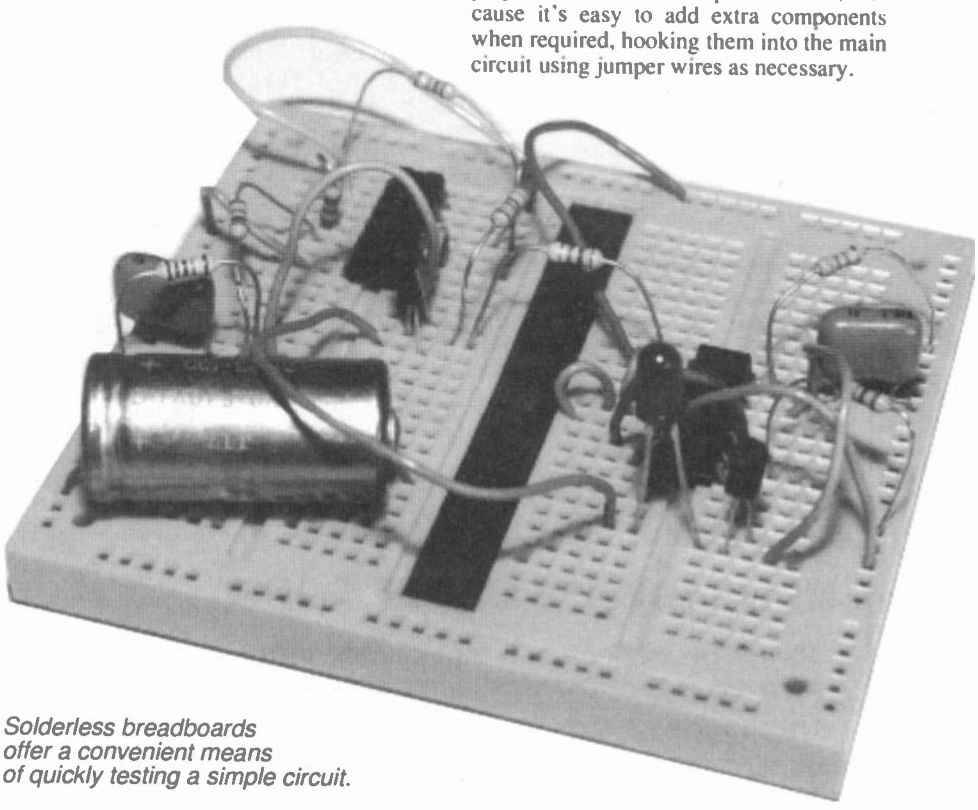
After finalising most circuit design aspects, a more permanent form of prototype can be considered. *Matrix board* (called *perfboard* in the USA) is simply a plain perforated Paxolin board, with holes drilled in a regular 0·1 inch matrix. Components are fed in from the top, and their wires soldered into a "rat's nest" underneath. It's crude and messy, but effective for quick experiments and projects.

Stripboard is useful for producing a more permanent circuit assembly. *Veroboard* is the brand name of probably the best known form of British-made stripboard, but there are some imported products which do the same job.

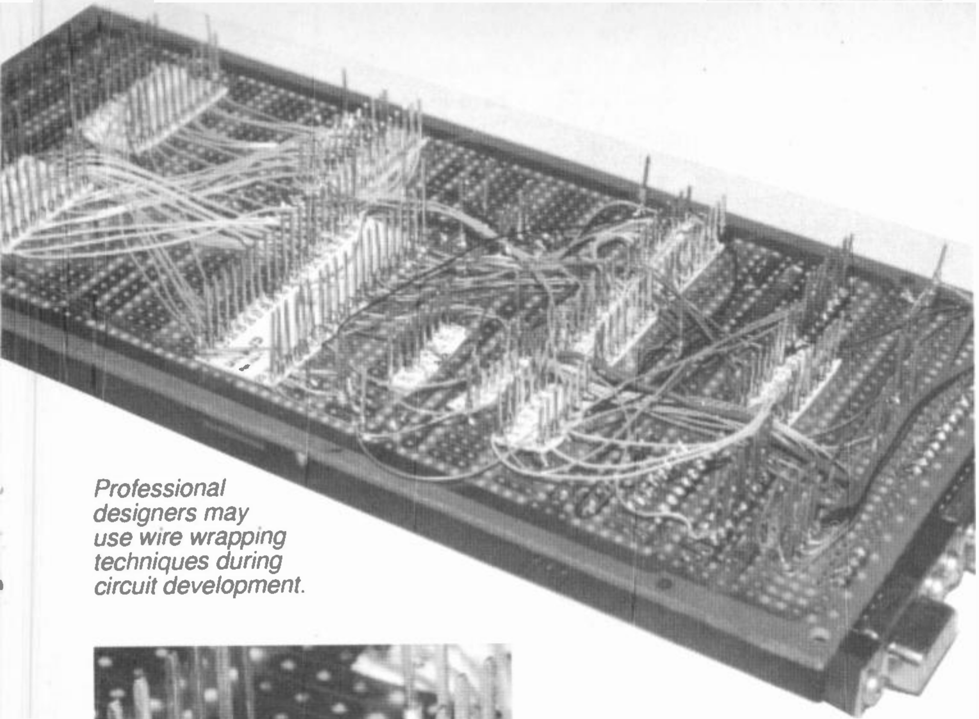
Stripboard (also known as *proto-board* in the USA) consists of a synthetic resin bonded paper (s.r.b.p.) board drilled in a regular grid, and with copper strips running underneath in one direction. Components are inserted from the top of the board with their leads and the copper strips on the underside, and soldered into position. (*An example of its use is shown in this month's* Vari-Colour Christmas Tree Lights *project – Ed.*)

By linking strips with solid wires, or cutting ("breaking") strips with a simple cutting tool to prevent short circuits, it's possible to fabricate complete circuits quite quickly and conveniently. The usual matrix of holes is 0·1 inch pitch, so ordinary dual-in-line (d.i.l.) integrated circuits will fit straight in without problems, as will most smaller discrete parts, including resistors, capacitors, transistors, etc.

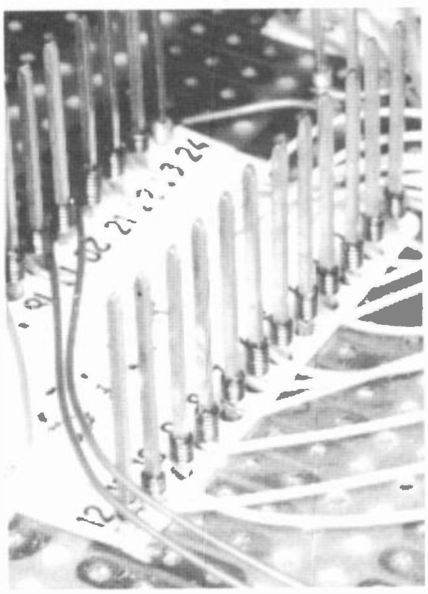
Stripboard is ideal for more modest projects and for development work, because it's easy to add extra components when required, hooking them into the main circuit using jumper wires as necessary.



Solderless breadboards offer a convenient means of quickly testing a simple circuit.



Professional designers may use wire wrapping techniques during circuit development.



Its main limitations are that it is easy to make mistakes: components can be soldered to the incorrect locations, adjacent strips can be accidentally shorted by excessive solder joints, and breaks in the strips can be imperfect or omitted altogether. Hence, troubleshooting a malfunctioning board can take ages while you double-check each and every joint, link and break!

By its very nature, ordinary stripboard is not a strong product, the perforations making a very good job of weakening the strength of the panel – thus it cannot support heavy or large components.

There are many variants of the "standard" stripboard, usually intended for use when digital integrated circuits are being interconnected during prototype development. Study a major professional supplier's catalogue and be prepared to be amazed at the variety!

WIRE WRAPPING

For very complex projects involving many digital integrated circuits, the use of stripboard and soldering the numerous link wires would be too unwieldy, time-consuming and inconvenient, and so before committing to a hard wired circuit, it's common to develop circuits using a system known as *wire wrapping*.

A high quality perforated board is used to carry the components, but devices are mounted via special sockets and terminals which have very long pins on the underside. A special wiring tool is used to twirl or wrap the stripped end of a connecting wire tightly around the pin to make a connection, then the other end is wrapped on its corresponding terminal on the circuit board.

The underside of the board soon resembles a plateful of psychedelic spaghetti, but it's a very quick and simple way of making multitudes of connections. The joints are also reliable and there is generally no need to solder them. You have to be at least 100 per cent alert, though, to ensure that you are connecting the right pins!

Wire wrapping will be familiar to University students, technicians and engineers but is less relevant in hobby circles.

You might also see prototyping pens or similar, which work in a slightly different way: an insulated length of wire is dispensed by the pen, being wrapped under tension around the pins, but then the wire has to be soldered in order to melt through the thin layer of insulation and form a joint.

THE P.C.B.

The form of interwiring which you will see used almost universally, is the *printed circuit board* (PC board or p.c.b.). These are usually made of glass-reinforced plastic (g.r.p.), and thus are immensely strong (unless weakened by many holes drilled in line, consider them unbreakable).

Normally, single-sided boards are used for project work, although more complex double-sided boards are occasionally seen. A single-sided board has a copper foil pattern on the underside only, with components placed on the upper side of the board, and this is fine for the majority of circuits.

A double-sided board will have copper track patterns on both sides of the board, and occasionally may be through-connected (plated-through-hole – p.t.h.) to the foil on the opposite side. This is necessary for more complex circuits or where a space-saving design is necessary, but it's fiddly, though not impossible, to produce this accurately at home.

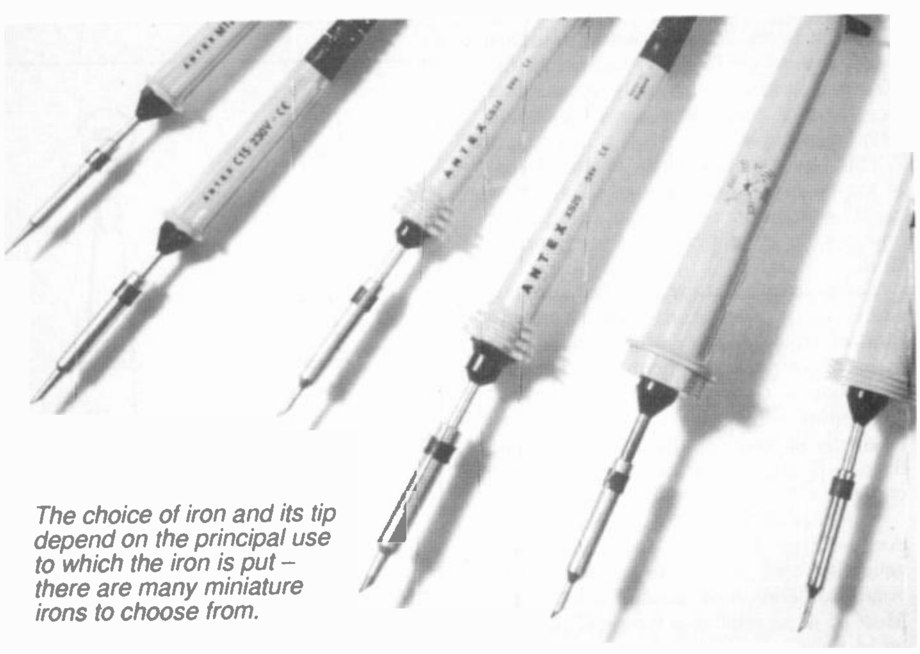
In industry, p.c.b.s having several layers of tracks sandwiched together are now common. The are generally referred to as *multi-layer boards* and require the use of extremely sophisticated manufacturing techniques. Resist the challenge of trying to make them yourself!

Techniques for fabricating one's own (single-sided) printed circuit boards will be outlined next month.

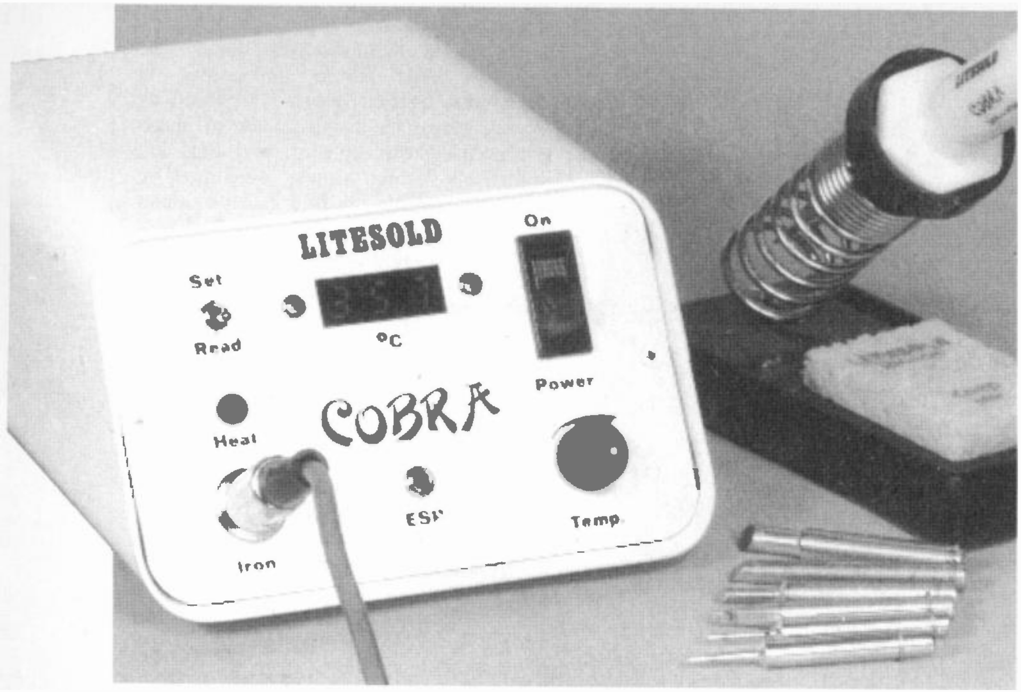
SOLDERING IRONS

Before delving any further into constructional techniques, the first and most important aspect of assembling any electronic project is that of *soldering*. It takes some practice to make the perfect joint, but, like riding a bicycle, once learned is never forgotten!

The idea is simply to join parts together to form an electrical and mechanically-sound connection, using a molten mixture of lead and tin (solder). A large range of soldering irons is available – which type is suitable for you depends on your application, your budget and how serious your interest in electronics is.



The choice of iron and its tip depend on the principal use to which the iron is put – there are many miniature irons to choose from.



For those with a serious interest in electronics a temperature controlled soldering station should be part of the workbench equipment.

Electronics catalogues often include a selection of well-known brands of soldering iron. Excellent British-made ones include the universally popular Antex and Litesold makes. Other popular brands include those made by Adcola, Weller and Ungar.

A very basic mains electric soldering iron can cost from under £5, but expect a reasonable model to be approximately £10-£12 – though it's possible to spend into three figures on a soldering iron station if you're really serious! Check catalogues for some typical types.

Certain factors you need to bear in mind include:

Voltage: Most irons run from the mains at 220V to 240V. However, low voltage types (e.g. 12V or 24V) generally form part of a soldering station and are designed to be used with a special controller made by the same manufacturer.

Wattage: Typically, irons may have a power rating of between 15W to 25W or so, which is fine for most work. A higher wattage does *not* (usually) mean that the iron runs hotter – it simply means that there is more power in reserve for coping with larger joints.

This also depends partly on the design of the bit (the tip of the iron). Consider a higher wattage iron simply as being more unstoppable when it comes to heavier-duty work.

Temperature Control: The simplest and cheapest types of iron don't have any form of temperature control. Simply plug them in and switch them on! Thermal regulation is designed in (by physics not electronics!): they may be described as thermally balanced so that they have some degree of temperature matching, but their output will otherwise not be controlled.

Unregulated irons form an ideal general purpose iron for most users, and they generally cope well with printed circuit board soldering and general interwiring. Most of these miniature types of iron will be of little use when attempting to solder large joints (e.g. very large terminals or very thick wires) because the component being soldered will sink heat away from the tip of the iron, cooling it down too much. (This is where a higher wattage comes in useful.)

A proper temperature-controlled iron will be quite a lot more expensive – retailing at, say, £40 or more – and will have some form of built-in thermostatic control, to ensure that the bit's temperature is maintained at a fixed level (within limits).

This is desirable, especially during more frequent use, since it helps to ensure that the temperature does not overshoot in between times, and also guarantees that the output will be relatively stable. Some irons have a bimetallic strip thermostat built into the handle which gives an audible click in use; other types use all-electronic controllers, and some may be adjustable using a screwdriver.

Yet more expensive still, *soldering stations* cost from £70 upwards (the iron may be sold separately, so you can pick the type you prefer), and consist of a complete bench-top control unit into which a special *low-voltage* soldering iron is plugged.

(A temperature-controlling soldering station will be presented as a constructional project in the future. Ed.)

Some versions might have a built-in digital temperature readout, and will have a control knob to enable you to vary the setting. The temperature could be boosted for soldering larger joints, for example, or for using higher melting-point solders (e.g. silver solder).

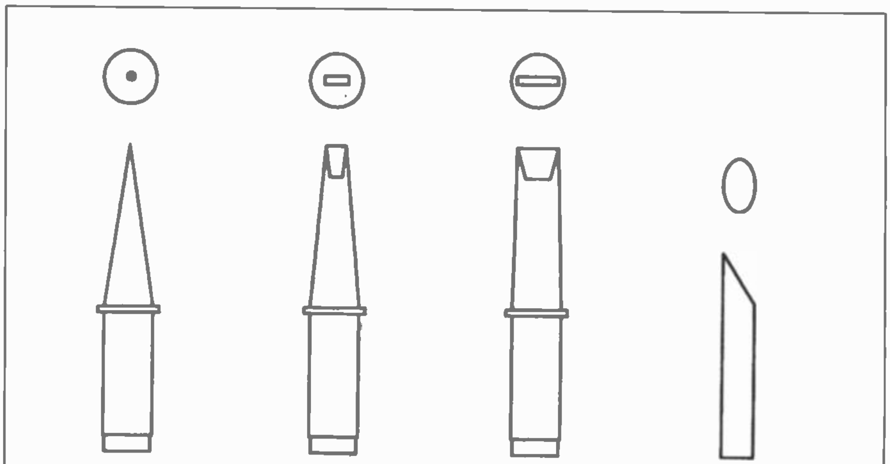
These irons are designed for the most discerning users, or for continuous production line/professional use. The best stations have irons which are well balanced, with comfort-grip handles which remain cool all day. A thermocouple will be built into the tip or shaft, which monitors temperature.

Anti-static protection: If you're interested in soldering a lot of static-sensitive parts (e.g. CMOS chips or MOSFET transistors), more advanced and expensive soldering iron stations use static-dissipative materials in their construction to ensure that static does not build up on the iron itself. You may see these listed as ESD safe *(electrostatic discharge proof)*.

The cheapest irons won't necessarily be ESD-safe but never-the-less will still probably perform perfectly well in most hobby or educational applications, if you take the usual anti-static precautions when handling the components. The tip would need to be well earthed in these circumstances.

Bits: It is useful to have a small selection of manufacturer's bits available with different diameters or shapes, which can be changed depending on the type of work in hand. You'll probably find that you become accustomed to, and work best with, a particular shape of tip. Often, tips are *iron-coated* to preserve their life.

Spare parts: It is nice to know that spare parts may be available, so if the element blows, you don't need to replace the entire iron. This is especially so with expensive irons. Also make sure that the bits can be *readily* changed - some which push *into*, rather than *onto*, the iron's shaft can become well-crudded and nigh-impossible to extract. Check through some of the



There are many variants on the shape and size of soldering iron bits available.

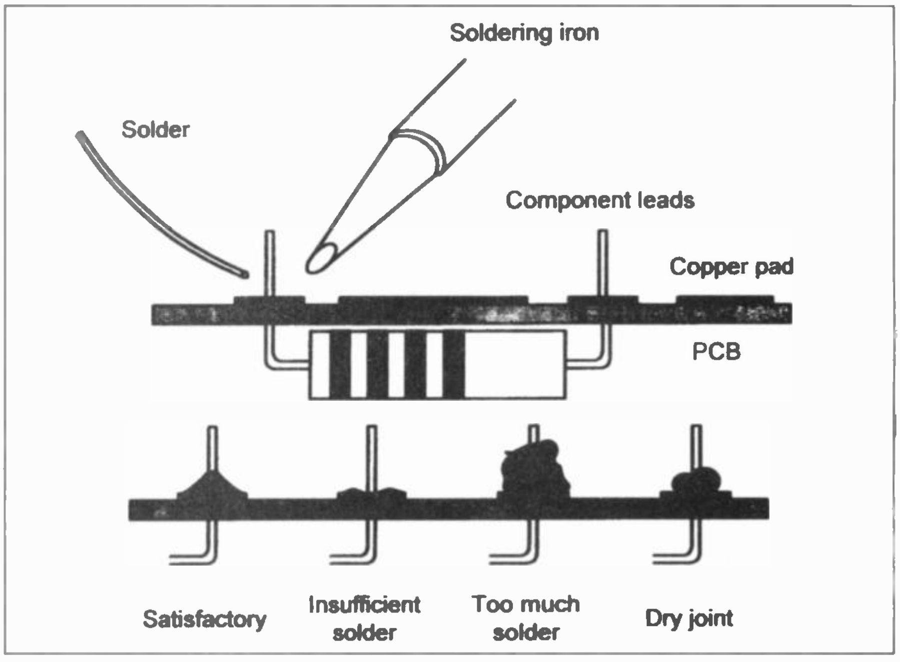
larger mail-order catalogues to ascertain the types of iron and associated spares available.

You will occasionally see *gas-powered* soldering irons which use butane rather than the mains to operate. They have a catalytic element which, once warmed up, continues to glow hot when gas passes over it. Service engineers use them for working on repairs where there may be no power available, or where a joint is tricky to reach with a normal iron, so they are really for occasional on-the-spot use for quick repairs, rather than for mainstream construction or assembly work.

A *solder gun* is a pistol-shaped iron, typically running at 100W or more, and is completely unsuitable for soldering modern electronic components. In fact, it's hard to think of where you *can* actually use them: they're certainly too hot, heavy and unwieldy for micro-electronics use. Plumbing, maybe..!

Soldering irons are best used along with a heat-resistant *bench-type holder*, so that the hot iron can be safely parked in between use. Soldering stations already have this feature, otherwise a separate soldering iron stand is essential, preferably one with a holder for tip-cleaning sponges.

Now let's look at how to use soldering irons properly, and how to put things right when a joint goes wrong.



The key to reliable electronics assembly and subsequent operation is good soldering.

HOW TO SOLDER

Turning to the actual techniques of soldering, firstly it's best to *secure the work* somehow so that it doesn't move during soldering and affect your accuracy.

In the case of a printed circuit board, various holding frames are fairly popular especially with densely populated boards: the idea is to insert all the parts on one side, hold them in place with a special foam pad to prevent them falling out, turn the board over and then snip off the wires with cutters before making the joints.

The frame saves an awful lot of turning the board over and over, especially with large boards. Other parts could be held firmly in a modeller's small vice, for example.

Joints may need to possess some degree of mechanical strength in some cases, especially with wires soldered to, say, potentiometer or switch tags, and this means that the wire should be looped through the tag and secured before solder is applied. The down side is that it is more difficult to desolder the joint (see later) and remove the wire afterwards, if required.

Otherwise, in the case of an ordinary circuit board, component wires are bent to fit through the board, inserted flush against the board's surface, splayed outwards a little so that the part grips the board, and then soldered.

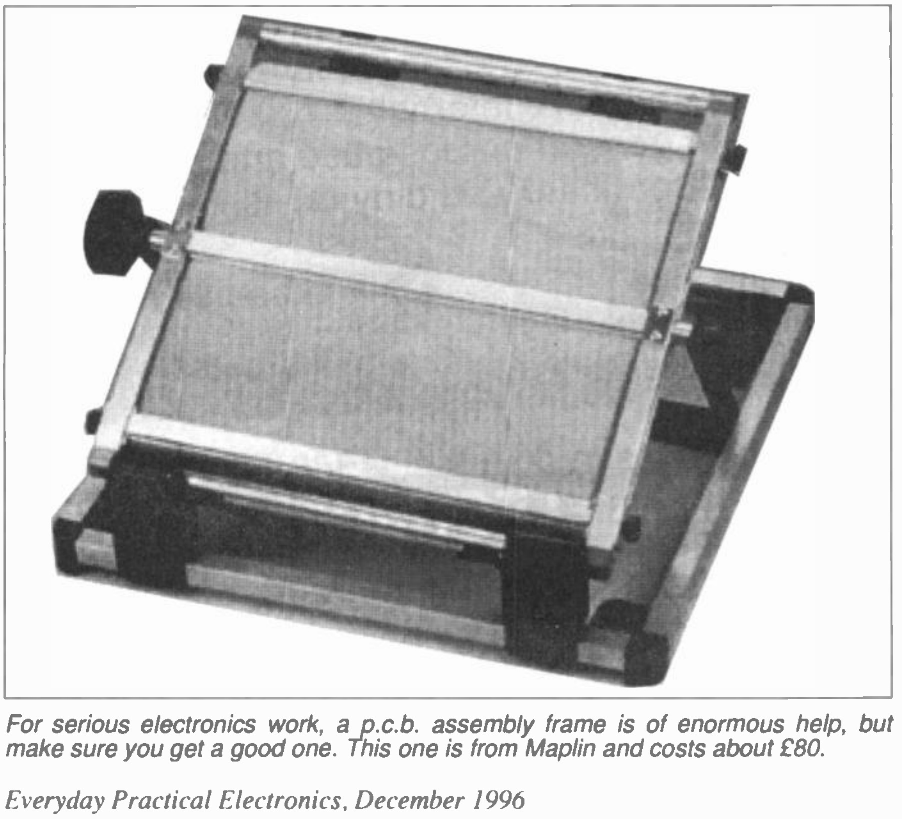
It's generally better to snip the surplus wire leads off first, to make the joint more accessible and avoid applying a mechanical shock to the p.c.b. joint. However, in the case of semiconductors, I often tend to leave the snipping until *after* the joint has been made, since the excess wire will help to sink away some of the heat from the semiconductor junction.

(Purists may argue that soldering should always *be done* after *trimming to length since this ensures that the trimmed end of the lead is protected by solder and cannot corrode over time. Ed.)*

Integrated circuits can either be soldered directly into place, if you are confident enough in your soldering ability (and that the device will never need replacing!), or better, use a dual-in-line socket to prevent heat damage. The chip can then be swapped out if needed.

Parts which become hot in operation (e.g. some resistors), should be raised above the board slightly to allow air to circulate. Some components, especially large electrolytic capacitors, may require a mounting clip to be screwed down to the board first, otherwise the part may eventually break off due to vibration.

The perfectly soldered joint will be nice and shiny looking, and will prove reliable in service. I would say that **cleanliness, temperature, time** and **adequate solder coverage** are the four key factors affecting the quality of the joint. A little effort spent now in soldering the perfect joint may save you – or somebody else – a considerable amount of time in troubleshooting a defective joint in the future. The basic principles are as follows.


For serious electronics work, a p.c.b. assembly frame is of enormous help, but make sure you get a good one. This one is from Maplin and costs about £80.

CLEAN

Firstly, and without exception, all parts – including the iron tip itself – must be clean and free from contamination. Solder just will not take to dirty parts! Old components or copper board can be notoriously difficult to solder, because of the layer of oxidation which builds up on the surface. This repels the molten solder, as will soon be evident, because the solder will bead into globules, going everywhere except where you need it. *Dirt is the enemy of a good quality soldered joint!*

Table 1.

How to make the perfect solder joint

- All parts must be clean and free from dirt and grease
- Secure the work firmly
- Clean the bit of the soldering iron on a damp sponge
- "Tin" the iron tip with a small amount of solder
- Heat ALL parts of the joint with the iron
- Only apply sufficient solder to form an adequate joint
- Return iron to stand
- It only takes two to three seconds to solder the average p.c.b. joint
- Do not move parts until solder cools

Problems

- Solder won't "take" – grease or dirt present – desolder and clean up. Or material is unsuitable for soldering with lead/tin solder
- Joint is crystalline – has been moved before cooling, or joint was not heated adequately
- Solder joint forms "spike" – has been overheated, burning away flux.

Hence, it is an absolute necessity to ensure that parts are free from grease, oxidation and other contamination. In the case of old resistors or capacitors, for example, where the leads have started to oxidize, use a small hand-held file, or perhaps scrape a knife blade, or rub a fine emery cloth over them, to reveal fresh metal underneath.

Stripboard and *copper* (untinned) printed circuit board will generally oxidize after a few months, especially if it has been fingerprinted. Copper strips can be cleaned using an abrasive rubber block, like an aggressive eraser, to reveal fresh shiny copper underneath. Only under extreme circumstances are *tinned* p.c.b.s likely to need cleaning in this fashion.

Also available is a fibre-glass filament brush, which is used in propelling-pencil fashion to remove any surface contamination. These tend to produce tiny particles which are highly irritating to skin, so avoid accidental contact with any debris. Afterwards, a wipe with a rag soaked in cleaning solvent will remove most grease marks and fingerprints. After preparing the surfaces, avoid touching them if at all possible.

Another unwanted side effect of having dirty surfaces is the tendency to want to apply more heat in an attempt to force the solder to take. This will often do more harm than good since it may not be possible to burn off some contaminants, and the component may be overheated. In the case of semiconductors, temperature is quite critical and they may be harmed by applying excessive heat, although most modern components are more tolerant of this than used to be the case.

Before using the iron to make a joint, it should be wiped first on a damp sponge to remove any contaminants, tinned by applying a few millimetres of solder, and then perhaps wiped again on the sponge to remove excess solder and flux. This prepares it for use; you should always do it immediately with a new bit, anyway.

As a hot tip (well, I had to!), I sometimes re-apply a small amount of solder again, mainly to improve the thermal contact between the iron and the joint so that the solder will flow more quickly and easily.

It's sometimes better to tin larger parts as well before making the joint itself, but it isn't generally necessary with p.c.b. work. (All *EPE* printed circuit boards are pre-tinned to preserve their quality and to help with soldering.)

A worthwhile product is Weller's *Tip Tinner & Cleaner*, a small five-gram tinlet of paste onto which you dab a hot iron – the product cleans and tins the iron ready for use.

The next step to successful soldering is to ensure that the temperature of all the parts is raised to roughly the same level before applying solder.

Imagine, for instance, trying to solder a resistor into place on a printed circuit board: it's essential to heat both the metallic p.c.b. track and the resistor at the same time before applying solder, so that the solder will flow much more readily over the joint. Heating one part but not the other is far less likely to produce a satisfactory joint, so strive to ensure that the iron is in contact with all the components first, before touching the solder to it.

NOW IS THE TIME

Finally, the joint should be heated with the bit for just the right amount of time – during which a short length of solder is applied to the joint. Solder contains a flux which helps the molten solder to flow more easily over the joint. *Too much solder* is an unnecessary waste and may cause short circuits with adjacent joints.

Too little and it may not support the component properly, or may not fully form a working joint. The heating period depends on the temperature of your iron and size of the joint – and larger parts need more heat than smaller ones – but some parts (semiconductor diodes, transistors and i.c.s), are sensitive to heat and should not be heated for more than a few seconds.

With practice, it will actually take one to three seconds at most to solder a component to a printed circuit board, depending on the size of joint.

Novices sometimes buy a small clip-on heat-shunt, which resembles a pair of aluminium tweezers. In the case of, say, a transistor, the shunt is attached to one of the leads near to the transistor's body. Any excess heat then diverts into the heat shunt instead of into the transistor junction, thereby saving the device from overheating. Beginners find them reassuring until they've gained more experience.

Finally, more serious enthusiasts and technicians, etc. may consider a *bench-top fume extractor* which draws excess solder fumes through a carbon filter, keeping the work area clear of smoke and fumes. They work very well but are relatively expensive.

The steps for making the perfect solder joint are shown in Table 1, along with a basic troubleshooting guide. There is no substitute for practice, though!

A soldered joint which is improperly made will be electrically noisy, unreliable and is likely to get worse in time. It may even not have made any electrical connection at all, or could work initially and then cause the equipment to fail at a later date!

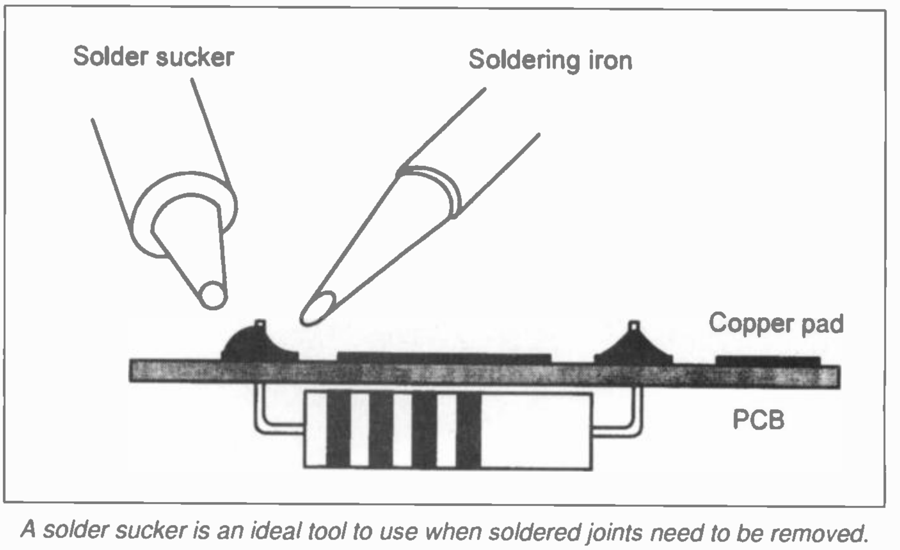
It can be hard to judge the quality of a solder joint purely by appearances, because you cannot say how the joint actually formed on the *inside*, but, by following the guidelines, there is no reason why you should not obtain perfect results.

A joint which is poorly formed is often called a dry joint. Usually it results from dirt or grease preventing the solder from melting onto the parts properly, and is often noticeable because of the tendency of the solder not to spread but to form beads or globules instead, perhaps partially.

Alternatively, if it seems to take an inordinately long time for the solder to spread, this is another sign of possible dirt and that the joint may potentially be a dry one.

DESOLDERING

There will undoubtedly come a time when you need to *remove* the solder from a joint: possibly to replace a faulty component or fix a dry joint. The usual way is to use a *desoldering pump* (or sucker) which works like a small spring-loaded bicycle pump, only in reverse!



A solder sucker is an ideal tool to use when soldered joints need to be removed.

A typical solder pump; the nozzle is seen at the right and the release button is just below the thumb.

Finally in this part of *Build Your Own Projects*, to complete the picture, you'll probably wish to consider a small selection of consumables, or what engineers call *service aids*. Looking on my bench, I've managed happily with a freezer aerosol (expensive, short-lived but handy for emergencies, especially when a desoldering pump is used), a compressed gas aerosol (e.g. Air Duster, which also has a short life but is useful to have), and an aerosol switch cleaner (e.g. Servisol or ElectroLube).

Super glue and epoxy adhesives are handy for both repairs and constructional work. A tin of non-flammable electrical cleaning solvent is useful for cleaning up boards etc., and catalogues include a range of other electro-chemical products, so you can increase the range as the occasion demands.

NEXT MONTH

In the next part, we check out ways of making your own printed circuit boards, and then start to investigate the preparation of cases and other bench procedures, ready for the completed board to be installed.

(More demanding users might need a pump which is ESD safe.)

A spring-loaded plunger is released at the push of a button and the molten solder is then sucked up into the pump. It may take one or two attempts to clean up a joint this way, but a small desoldering pump is an invaluable tool, especially for p.c.b. or stripboard work.

In many cases, a desoldering braid can be used instead of a desoldering pump.

Sometimes, it pays to actually *add more* solder and then desolder the whole lot with a pump, if the solder is particularly awkward to remove. Care is needed, though, to ensure that the boards and parts are not damaged by excessive heat; the pumps themselves have a P.T.F.E. nozzle which is heat proof. However, with constant use the nozzles can be become distorted, preventing adequate suction from taking place.

An excellent alternative to a pump is to use *desoldering braid*, including the famous Soder-Wick which is packaged in small dispenser reels. This product is a specially treated fine copper braid which is applied to the molten joint, and the solder will be drawn up with surprising effectiveness. I recommend buying a small reel, especially for difficult joints which would take several attempts with a pump.

Be aware, though, that incautious use of the braid, by applying too much pressure to it, or roughly drawing it across the joint, can damage and even break delicate p.c.b. tracks.

Table 2.

All about solder

- Normal electronics solder is 60%/40% tin-lead mixture
- It contains cores of flux to help it to flow when molten
- Melting point is typically 188°C
- Tip temperatures needed are roughly 330° to 350°C
- The larger the standard width guage, the *thinner* the solder

S.W.G.	*Diameter (mm)*
13	2.34
14	2.03
16	1.63
18	1.22
20	0.91
22	0.71
24	0.56
26	0.46

- 20-22 s.w.g. is fine for most p.c.b. work, 18 s.w.g. for larger joints

Constructional Project

STEREO CASSETTE RECORDER

ROBERT PENFOLD

Build your own cassette recorder around a "surplus" deck and this high quality circuit. One for the experimenter.

In the last 20 years or so, there seems to have been few (if any) published designs for tape recorders. Some 20 to 30 years ago several tape recorder designs were published, and they were quite popular.

One probable reason for the demise of home constructed recorders is that new cassette deck mechanisms have been virtually unobtainable for many years. The few that have been available were invariably high quality and very expensive types. Together with the falling cost of ready-made cassette recorders, this has made do-it-yourself units a less attractive proposition than was once the case.

ABSORBING PROJECT

On the other hand, a cassette recorder is still a very absorbing project to tackle, and interest in this type of project would seem to be far from dead. This Stereo Cassette Recorder project was produced in response to a steady flow of readers' letters requesting a project of this type.

Although new cassette deck mechanisms are currently unobtainable, there seems to be an almost constant flow of decks onto the surplus market. Many of these cost just a few pounds each, complete with heads and motor. I have also removed a perfectly good deck from a "dumped" cassette/radio that had come to a premature end due to an electronic fault that would have been too expensive to have repaired.

It is standard advice to obtain any awkward parts before buying the rest of the components for a project. In this case it is clearly essential to obtain a suitable cassette mechanism before proceeding to buy the other parts.

Having obtained a cassette mechanism, you need to carefully assess its potential before proceeding further. A deck removed from a piece of defunct equipment should be complete with heads, motor, etc., and should be suitable for a do-it-yourself cassette recorder, *provided it is working and in reasonably good condition.*

Surplus cassette mechanisms seem to vary enormously, but in order to realistically use one of these units as the basis of a "do-it-yourself" cassette deck it is necessary to have one that is largely complete. In other words, choose a deck that is complete with a motor, record/playback and erase heads, plus all the mechanical parts.

A deck that has a mono record/playback head can be used for stereo operation if the head is replaced with a stereo type. Provided it has the standard mounting arrangement, replacing the head is not difficult, but it is likely to be much more expensive than obtaining a deck that is ready fitted with a stereo record/playback head. The erase head is the same for mono and stereo recorders, incidentally.

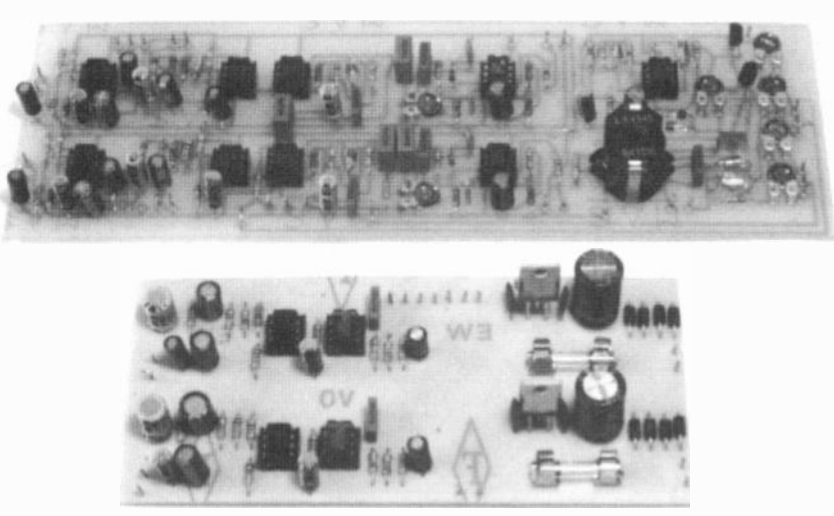
PLAY ONLY

Bear in mind that there are two types of cassette mechanism. The simpler type normally has five rather than the full set of six buttons or levers, and they are only intended for *playing* tapes, not recording them.

Some of these play-only units have the full complement of six levers or buttons, but one of them is either non-functioning, or simply duplicates the action of the "play" button. The "record-protect" mechanism at the rear of the unit will be missing. The erase head will also be missing, or a dummy type to act as a tape guide will be fitted.

It is probably not worthwhile trying to upgrade a play-only unit for operation in a recorder. A mechanism of this type can be used as the basis of a cassette player though, and should provide excellent results.

This cassette recorder project is based on two printed circuit boards, one of which carries the power supply and playback amplifier circuits. Only this board is needed if you intend to build just a cassette player.



Completed Record/Erase (top) and Playback/PSU boards.

RECORD/PLAYBACK

If you intend to build a unit capable of recording and playing back tapes, it is essential to have at least one set of switch contacts that are activated only when the mechanism is set to the "record" mode. The number of contacts fitted seems to vary substantially from one deck to another. There will usually be one or two sets of contacts that close whenever the mechanism is activated.

When using a battery powered unit these can be used to automatically switch on the motor and electronics when the deck is used. For a mains powered unit they are not too important. The motor and (possibly) the electronics are left running continuously so that the deck can provide an "instant" start-up.

There may be several contacts that are controlled by the "record" lever, and these can then provide the record/playback switching. This is unlikely though, and usually just a single set of normally open contacts are provided. These are used to control the record/playback switching either via electronic switching, or a relay.

This tape recorder circuit is intended for control via a relay if the deck lacks sufficient contacts for direct control. If the mechanism lacks a set of contacts that are only operated by the "record" lever, it can only be used in a recorder if you can find a means of adding a microswitch to control the record/playback switching. Provided the deck mechanism is otherwise complete, this should not be too difficult.

TURN OF SPEED

It seems to be the norm for the motors used in cassette mechanisms to have built in speed regulation circuits. In some cases the speed is preset at the correct figure, and you simply have to connect a suitable supply with the correct polarity. A substantial percentage of cassette deck motors seem to have two large supply tags, plus two smaller tags. The latter seem to be for use with an external speed control, and a 4k7Ω (4·7 kilohms) preset (wired as a variable resistor) connected between them usually gives the desired effect.

With some motors the speed control is optional, and the motor defaults to a suitable speed if the preset potentiometer is omitted. With motors of this type it is probably best just to leave these tags unconnected.

With other motors it is essential to add the speed control, since without it the motor runs much too fast. In fact it will probably run at something approaching twice the required speed.

The best way to set the correct speed is to record a test tone at about 1kHz using any cassette recorder that is in good working order. Play the tape back on the do-it-yourself recorder, and compare the reproduced tone with that from the original signal source. Then simply adjust the speed control so that the played-back tone is the same as the original tone.

UNKNOWN QUANTITY

This article is primarily concerned with the electronics for a cassette recorder, and details of the mechanical side of construction are not provided. It would be impractical to do so, since the cassette mechanism is something of an unknown quantity. These units vary considerably in size and shape, and in most cases it will be necessary to use a certain amount of ingenuity in order to get the mechanism securely mounted in a case and working well.

However, it is worth making one or two general points about the mechanical side of construction. The cassette mechanism is unlikely to hold the cassettes in place properly, except in the case of some up-market front loading types. You will normally have to provide side pieces to prevent the cassette from skewing round slightly when the tape heads are engaged.

Also, a sprung cover over the cassette compartment is needed. This keeps out dust when the unit is not in use, and holds the cassette down on the mechanism when it is.

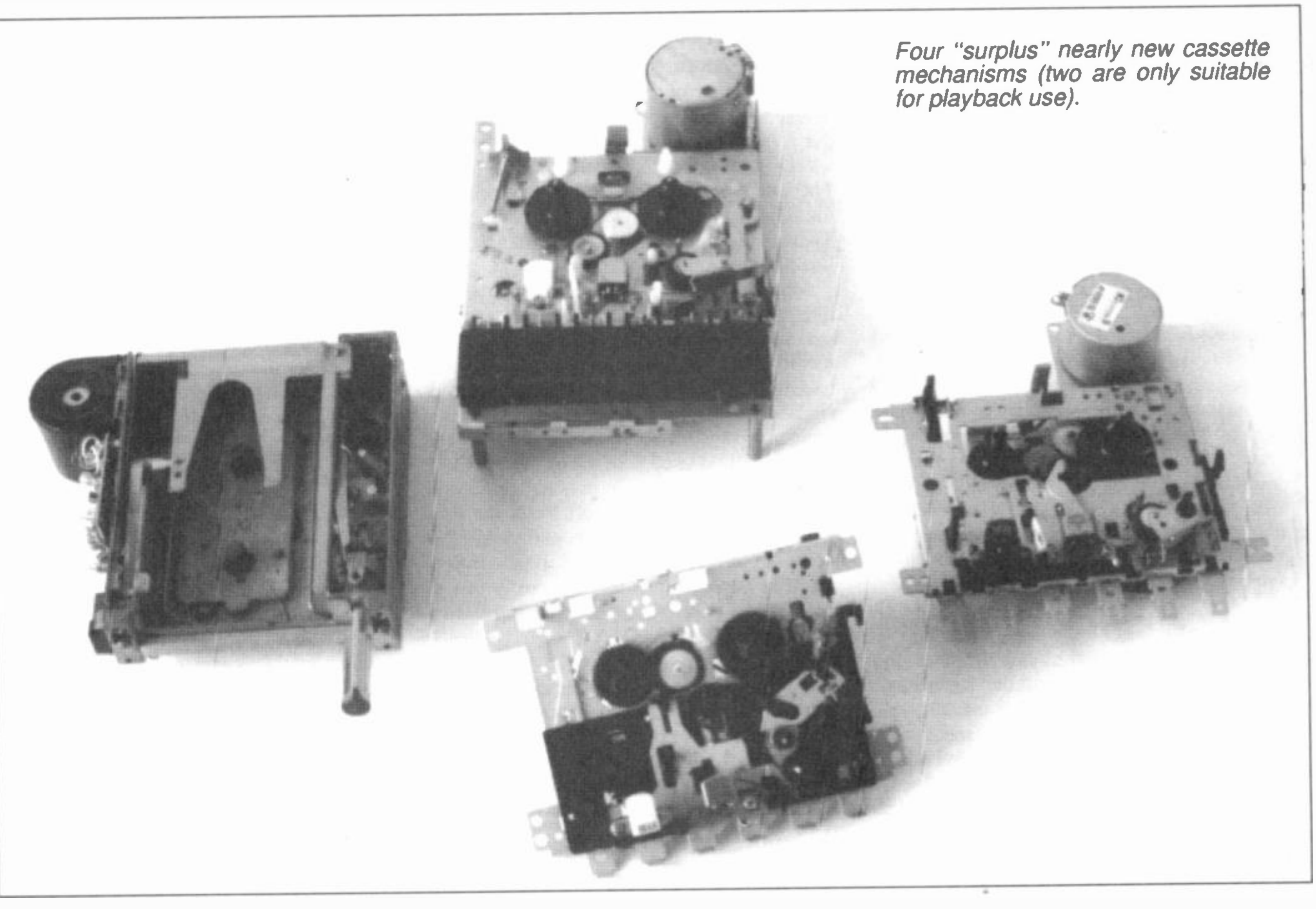
On ready-made recorders the side cheeks and lid are usually in one assembly. The cassette is inserted into the lid assembly and closing the lid then takes the cassette down into position. Life will be a lot easier if the cassette holder is included with the cassette mechanism, but it usually seems to be absent. Unless the cassette is held firmly in position during use it is likely that a lot of mangled tapes will be produced!

TAKE NOTE

One final, but important, point is that this project is not intended for beginners, unless carefully supervised. The circuits have been kept reasonably straightforward, but this is still a fairly complex piece of electronics having a mains power supply.

It is possible to get usable results without the aid of any test equipment, but in order to obtain optimum results it is necessary to have access to some audio test gear. Ideally, an audio sinewave generator and an oscilloscope should be available, together with a knowledge of how to use them.

The circuits provided here are all tried and tested, but this project is primarily aimed at those who like to experiment.



Four "surplus" nearly new cassette mechanisms (two are only suitable for playback use).

SYSTEM OPERATION

The block diagram shown in Fig. 1 helps to explain the way in which the Stereo Cassette Recorder functions. In order to keep the record/playback switching as simple as possible, separate recording and playback amplifiers are used.

When used in the "play" mode, the unit is very simple since most of the stages are switched off, or provide no useful function. The only stage that it is absolutely essential to switched off is the "erase oscillator", which, of course, would otherwise erase the tape being played!

The second function of this oscillator is to provide a high frequency bias signal to the record/playback head when recording. This is necessary to counteract the inherent non-linearity of a magnetic recording system. The exact frequency of the erase/bias signal is not that important, and most tape heads will work satisfactorily with a frequency of around 50kHz to 100kHz.

Quite a high signal level is needed in order to drive the erase head properly. Typically some 10V to 12V r.m.s. is needed at a current of about 40mA to 50mA. The basic erase oscillator is a simple Wien sinewave type which cannot provide a high enough drive voltage or current. It therefore drives the erase head via a simple complementary class-B output stage and a step-up transformer. This enables the erase head to be driven with a good quality sinewave signal at anything from about 25V to 40V peak-to-peak.

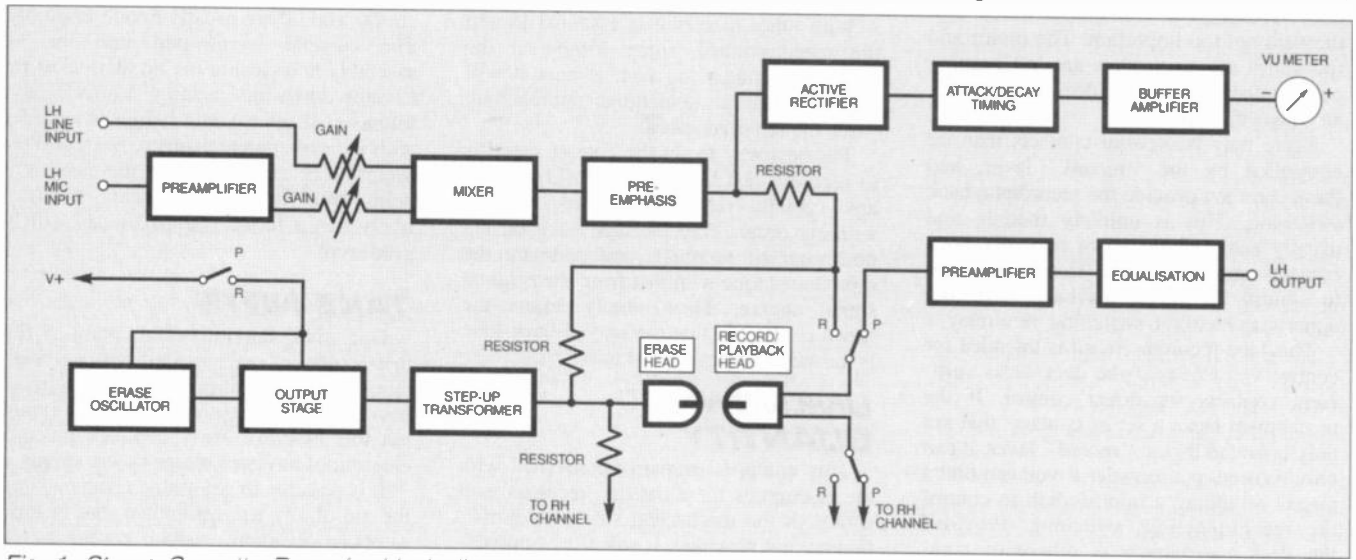


Fig. 1. Stereo Cassette Recorder block diagram. Only the left channel is shown, the right channel is identical. The erase oscillator is common to both channels.

During "playback" mode, the only stages which are used are the playback preamplifier and equalisation circuits. These are duplicated in the two stereo channels, as are most other stages.

The output level from a tape head is quite low, and is typically a little under one millivolt peak-to-peak. The preamplifier provides a voltage gain of just over 20, and the equalisation provides further voltage gain. This stage also provides a large amount of treble cut, which counteracts the treble boost (pre-emphasis) used during the recording process.

The treble boost and cut gives a flat overall frequency response, and the treble cut used during playback gives a useful reduction in the background "hiss".

Additionally, the equalisation has to compensate for the frequency response of the tape head. This gives an output that rises at 6dB per octave. In other words, a doubling of the signal frequency gives a doubling of the output level. The output level from the playback circuit is typically a little over one volt r.m.s., which should be sufficient to drive any normal hi-fi amplifier.

ERASE OSCILLATOR

Two identical signal chains are used in the two stereo channels of the recording circuit, but the erase oscillator circuitry is common to both channels. The erase oscillator serves two functions, and obviously one of these is to drive the erase head. The erase head is positioned ahead of the record/playback head, to ensure that recordings are always made onto blank tape, even when a tape is being reused.

A simple two input mixer is at the heart of each recording amplifier. One input of the mixer is designed for use with a high level signal source such as an f.m. tuner. The other input is fed from a microphone via a high gain microphone preamplifier. There are separate gain controls for the line and microphone signals.

Many cassette recorder circuits have the line input provided via the microphone input and an attenuator. This is a simple method, but the noise of the microphone preamplifier gives a significantly reduced signal-to-noise ratio when using the line input.

The method used here gives much better results, because the microphone gain controls can be fully backed-off when the line input is in use. This totally eliminates the noise from the microphone preamplifier. Another advantage of this system is that it enables the microphone and line signals to be mixed at the desired levels.

The output from each mixer is fed to a low gain amplifier, and these amplifiers provide the pre-emphasis. They also drive the record/playback head.

There is a slight problem in driving the tape head in that it provides a highly inductive load. This means that a given drive voltage will provide a much higher current flow at a low frequency than at a high frequency. In order to overcome this problem it is necessary to use a constant current drive circuit.

The most simple way of achieving the desired result is to feed each channel of the tape head via a high value resistor. Provided the value of the resistor is many times higher than the high frequency impedance of the tape head, the current flow will be largely governed by the series resistors. The high value of the resistors swamps the variations in the tape head's impedance.

The erase/bias oscillator also feeds each channel of the record/playback head via a high value resistor. The resistors form simple passive mixers which combines the audio and high frequency bias signals.

Manual rather than automatic recording level control is used, because the manual type is simpler and generally gives much better results when recording music. The recording level meters are of the peak reading variety, and the two stereo channels are identical.

The output from the pre-emphasis amplifier is fed to a half-wave active rectifier. This feeds into a smoothing circuit which provides the standard attack and decay times of 2·5ms and one second respectively.

This relatively fast attack and slow decay enables the circuit to respond properly to brief but strong signals which can be missed by average reading meters. The meter movement is driven via a buffer amplifier which ensures that the long decay time of the smoothing circuit is not shortened by loading effects.

PLAYBACK AMPLIFIER

The circuit diagram for the Playback Amplifier appears in Fig. 2. The two stereo channels are identical, so we will only consider the left hand channel here.

Switch S1 provides the record/playback switching. This can either be switch contacts on the cassette mechanism, or relay contacts. Using a relay to provide this switching is considered in detail later.

IC1 is a very low noise, almost distortion free, operational amplifier (op.amp) which is specifically designed for use in low-noise audio preamplifiers. It is used here as a straightforward non-inverting mode amplifier having an input impedance of about 5kΩ (five kilohms) or so and an open loop voltage gain of about 22 times.

The output of IC1 is direct coupled to the input of IC2, which is another very low noise, low distortion, op.amp. This circuit is also used in the non-inverting mode.

Resistors R6 and R7 set the voltage gain at about 1000 times, but this is significantly reduced at all but the lowest frequencies by the inclusion of equalisation components capacitor C6 and resistor R9. These reduce the voltage gain to about 30 times at high frequencies.

In theory, the equalisation must provide a 6dB per octave roll-off across the whole audio spectrum to compensate for the 6dB per octave rise in output level from the tape head. Further treble cut is needed in order to counteract the pre-emphasis used during the recording process.

Things are very different in practice due to the inefficiency of the tape head at higher frequencies. In fact the output from a typical tape head starts to fall away at middle audio frequencies. Consequently, the equalisation must only be maintained over the lower and middle audio range.

There is no standard replay characteristic, since the required frequency response for the playback amplifier has to take into account the frequency response of the tape head used, and the desired bandwidth of the system. Good results should be obtained with the specified values for C6 and R9, but it will probably be possible to obtain a flatter response by "tweaking" these values slightly.

With a high quality tape head, it should be possible to obtain something approaching the full 20kHz audio bandwidth. It is not a good idea to try to force the full 20kHz bandwidth from a tape head of lesser quality. This may actually be possible, but only at the expense of a poor signal-to-noise ratio.

In order to keep the circuit relatively simple and straightforward, the unit does not incorporate any form of noise reduction circuitry. Due to the increased quality provided by modern tape heads, tapes, and electronics, this is a less serious omission than it would have been a few years ago. Even without resorting to noise reduction

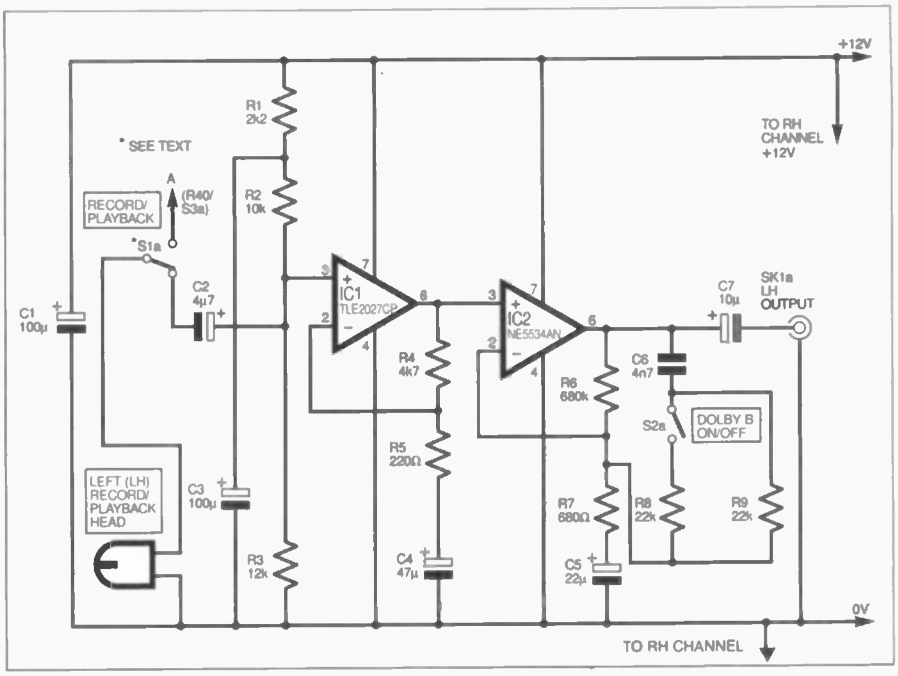


Fig. 2. Circuit diagram for the Playback Amplifier of the Stereo Cassette Recorder.

it is possible to obtain a signal-to-noise ratio of about 60dB to 70dB, which is adequate for most purposes.

Switch S2 should be closed when playing Dolby-B encoded tapes. This increases the high frequency roll-off slightly, which avoids the excessive treble which will otherwise be obtained.

If the ultimate in performance is not required, an NE5534A op.amp can be used for IC1 (and IC3), and a bifet device such as an LF351N or TL071CP can be used for IC2 (and IC4). This provides a useful reduction in cost with only a marginally higher noise level.

Using inexpensive devices such as the µA741C, LF351N, etc. for IC1 (and IC3) is not to be recommended. Devices such as these will provide a significantly higher noise level than the TLE2027CP or NE5534AN.

ERASE OSCILLATOR

The circuit diagram for the Erase/Bias Oscillator appears in Fig. 3. IC5 is used in a conventional Wien oscillator circuit. The operating frequency is governed by the values of capacitors C17 and C18, and resistors R21 and R23. The specified values give an output frequency of around 70kHz to 80kHz.

Preset VR1 is adjusted to provide an output signal of the required amplitude, with diodes D1 and D2 providing a certain amount of gain stabilisation. Transistors TR1 and TR2 form the complementary class-B output stage.

In order to obtain a high enough drive voltage for the erase head, a step-up transformer (T1) must be used. Resistor R25 limits the drive current to T1, which otherwise tends to produce a slightly excessive output level.

Capacitor C20 brings the tape head and secondary of T1 to resonance at the appropriate frequency, and this greatly improves the quality of the sinewave output signal. It might be necessary to alter the value of C20 to optimise results with some erase heads, but a value of 10nF (nanofarads) gave good results with several different erase heads.

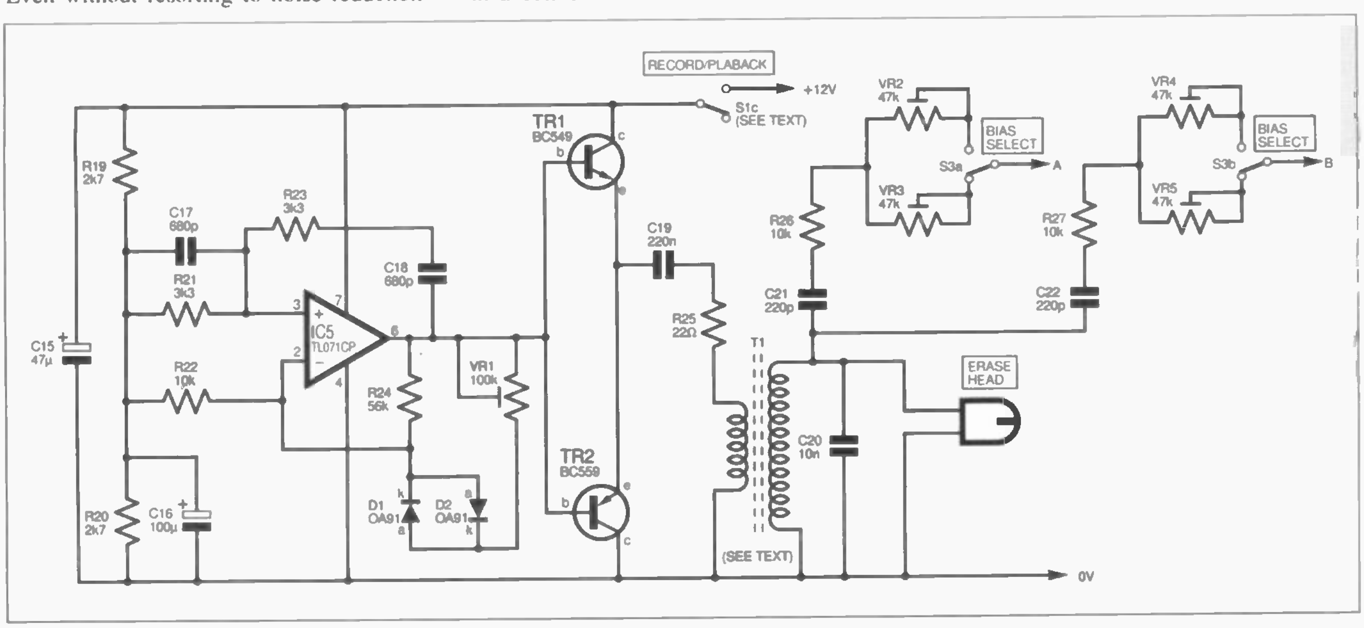


Fig. 3. Circuit diagram for the Erase/Bias Oscillator stage. This circuit serves both channels.

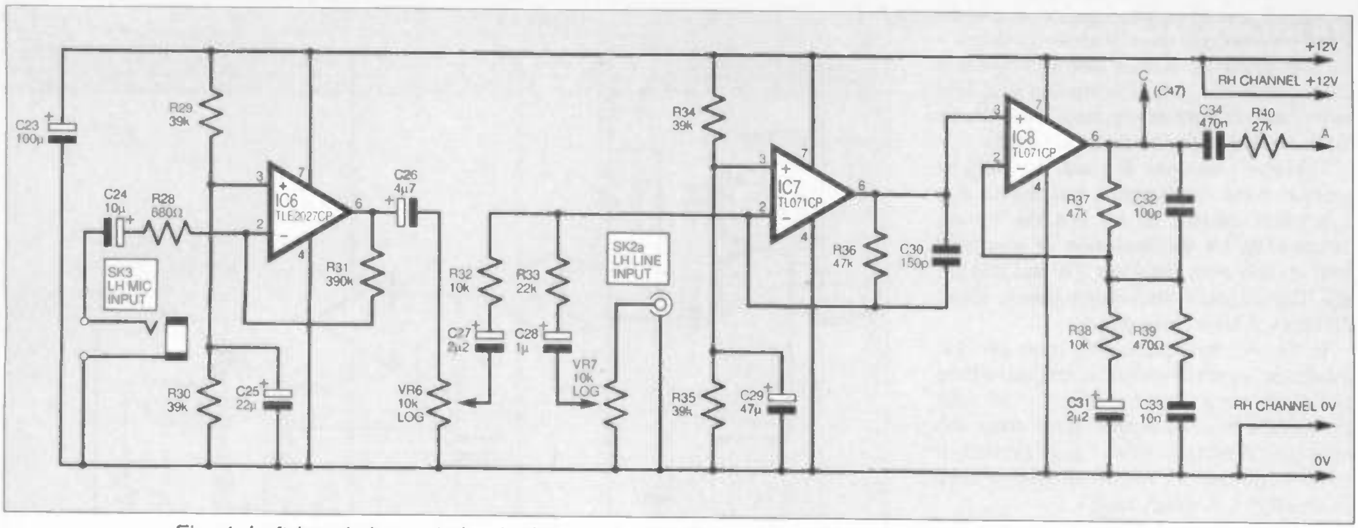


Fig. 4. Left-hand channel circuit diagram for the Record Amplifier. The right channel is identical.

The only exceptions were a couple of old heads from mono cassette decks. These seem to have a higher impedance than modern erase heads. Apart from tuning problems, they also seem to require a higher drive voltage than this circuit can provide. If the cassette mechanism is fitted with a head of this type it is probably better to replace the erase head with a modern type rather than try to modify the driver circuit to suit the old head.

Capacitor C21, resistor R26 and either preset VR2 or VR3 couple the bias signal to the left hand section of the record/playback head. Capacitor C22, resistor R27, together with presets VR4 and VR5, provide the same function in the right hand channel.

The point of using two preset resistors plus selection switch S3 is that it enables two bias levels to be used, so that the deck can be used with two different types of tape. These will usually be normal ferric tapes and chromium dioxide tapes. The latter require a higher bias level. Although the bias signal is fed to the tape head via fairly high resistances, the bias level is quite high. In fact the bias level is about ten times higher than the audio signal.

RECORD AMPLIFIER

Refer to Fig. 4 for the Record Amplifier circuit diagram. Again the two channels are identical, and only the left hand channel will be described. IC6 is a low noise and low distortion op.amp which is used as the basis of the microphone preamplifier. It is used in a simple inverting mode circuit. The circuit is designed for use with a *low* impedance microphone, such as a dynamic or electret type which does not have a built-in step-up transformer.

Like a tape head, the output level from a microphone is likely to be less than one millivolt peak-to-peak. Op.amp IC6 must therefore provide a substantial amount of voltage amplification. Resistor R28 and R31 set the input impedance of the circuit at 680 ohms, and the closed loop voltage gain at a little under 600 times.

The mixer stage has IC7 in a conventional summing mode circuit. Potentiometers VR6 and VR7 are respectively the microphone and line level controls. IC7 boosts the microphone signal by a factor of just under five times. There is a voltage gain of a little over two times from the line input to the output of IC7.

Less than one volt peak-to-peak is needed at the line input in order to fully drive the unit. Capacitor C30 provides a small amount of high frequency roll-off which helps to avoid problems with any high frequency input signals reacting with the bias signal to produce heterodyne tones.

The output of IC7 is direct coupled to the input of the pre-emphasis amplifier. This is based on IC8, which is used in the non-inverting mode. Its basic voltage gain is set at about six times by resistors R37 and R38, but resistor R39 and capacitor C33 produce a substantial amount of boost at high audio frequencies. In fact it provides almost 20dB of boost at the highest audio frequencies. Capacitor C32 and resistor R39 tame the response of the amplifier at frequencies above the upper limit of the audio range.

Capacitor C34 couples the output of IC8 to the tape head via series resistor R40. As explained previously, this resistor is needed in order to provide a constant current drive to the tape head.

This resistor obviously introduces large losses, but the tape head needs a typical drive current of only about 40 microamps or so. Even with the losses through R40, less than 2V r.m.s. at the output of IC8 is sufficient to drive the tape head properly.

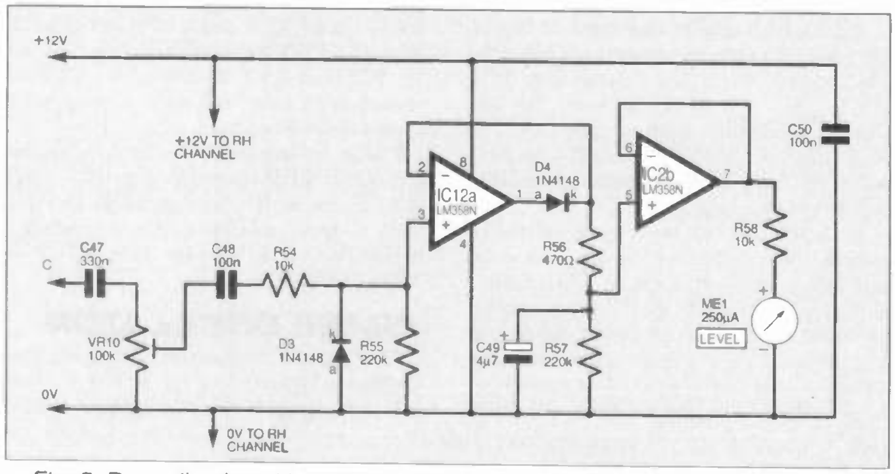


Fig. 5. Recording Level left channel circuit diagram. Right channel is repeated.

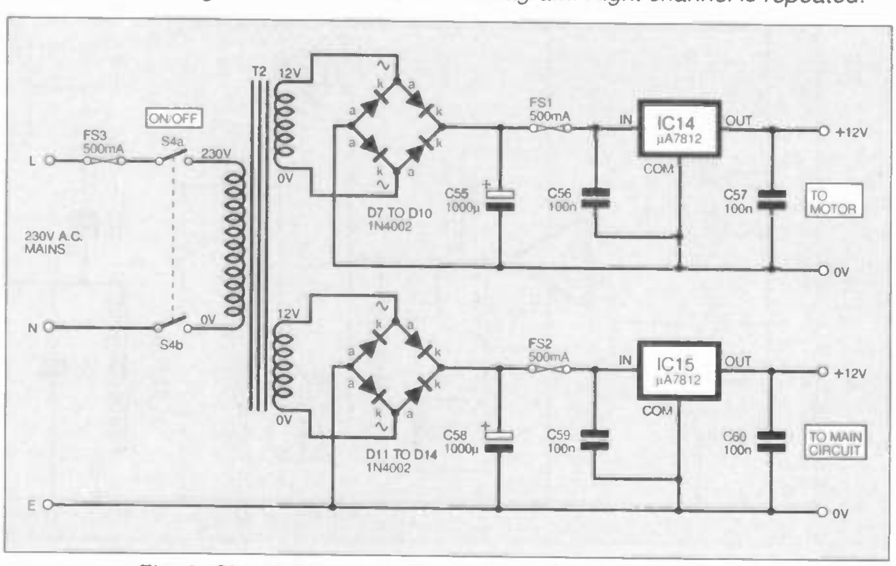


Fig. 6. Circuit diagram for the twin regulated power supply.

LEVEL METERS

The circuit diagram for the recording level meters is shown in Fig. 5. Once again the two stereo channels are identical, and only the left hand channel will be described.

Preset VR10 is a variable input attenuator that enables the sensitivity of the circuit to be set at a suitable level. The output from VR10 is coupled to a conventional half-wave active rectifier based on IC12a. The LM358N used for IC12 permits operation from a single 12V supply, but this circuit will not work properly with most other dual op.amps (LM1458C, LF353N, etc.).

Capacitor C49 is the smoothing component. Resistors R56 and R57 respectively set the attack and decay times at approximately the required figures of 2·5ms and one second. IC12b acts as a buffer stage between the smoothing circuit and the meter circuit.

The meter circuit should have a full scale sensitivity of about 2·5V. If the meter used has a full scale sensitivity of other than 250µA it will be necessary to alter the value of resistor R58 to suit.

POWER SUPPLY

The circuit diagram for a mains power supply unit for the electronics and motor is provided in Fig. 6. It is not essential to have largely separate supplies for the motor and the electronics, but this method virtually guarantees that there are no problems with electrical noise from the motor finding its way into the audio signal paths.

Mains transformer T2 has twin secondary windings which drive two identical regulated supplies; one for the electronics and one for the cassette deck's motor.

Full-wave bridge rectification is used, with smoothing provided by C55 and C58. Electronic smoothing and regulation is provided by two 12 volt monolithic voltage regulators (IC14 and IC15). The foldback current limiting of the regulators provides protection against short circuits on the outputs, and further protection is provided by fuses FS1 and FS2.

The maximum output current from each supply is about 250mA or so. The current consumption of the electronics is no more than about 100mA, but if a relay is used to provide the record/playback switching, this can virtually double.

The current consumption of a 12V cassette deck motor is usually about 100mA in normal use. Some motors might require a somewhat higher current though, particularly those that have solenoids for automatic loading and ejecting of tapes, or other up-market features.

If the cassette mechanism has a 6V motor, it is probably best to power the main supply from a 12V 500mA mains transformer (or a component having two 6V 500mA secondaries wired in series), and to omit all the components for the motor's supply circuit. The motor would then have to be powered from an entirely separate 6V supply.

Alternatively, IC14 can be replaced with a 7808 regulator, which will provide an output of 8V to the motor. This is somewhat higher than the rated voltage of the motor, but the built-in speed regulators of 6V decks seem well able to cope with

COMPONENTS

Resistors

R1, R10	2k2 (2 off)
R2, R11, R22, R26, R27, R32, R38, R45, R51, R54, R58, R59, R63	10k (13 off)
R3, R12	12k (2 off)
R4, R13	4k7 (2 off)
R5, R14	220Ω (2 off)
R6, R15	680k (2 off)
R7, R16, R28, R41	680Ω (4 off)
R8, R9, R17, R18, R33, R46	22k (6 off)
R19, R20	2k7 (2 off)
R21, R23	3k3 (2 off)
R24	56k
R25	22Ω
R29, R30, R34, R35, R42, R43, R47, R48	39k (8 off)
R31, R44	390k (2 off)
R36, R37, R49, R50	47k (4 off)
R39, R52, R56, R61	470Ω (4 off)
R40, R53	27k (2 off)
R55, R57, R60, R62	220k (4 off)

All 0·25W 5% carbon film, or better

See SHOP TALK Page

Potentiometers

VR1, VR10, VR11	100k min. preset, horiz. (3 off)
VR2 to VR5	47k min. preset, horiz. (4 off)
VR6 to VR9	10k rotary carbon log. (4 off)

Capacitors

C1, C3, C8, C10, C16, C23, C35	100µ radial elect., 16V (7 off)
C2, C9, C26, C38, C49, C53	4µ7 radial elect., 50V (6 off)
C4, C11, C15, C29, C41	47µ radial elect., 25V (5 off)
C5, C12, C25, C37	22µ radial elect., 25V (4 off)
C6, C13	4n7 polyester (2 off)
C7, C14, C24, C36	10µ radial elect., 25V (4 off)
C17, C18	680p polystyrene (2 off)
C19	220n polyester
C20, C33, C45	10n polyester (3 off)
C21, C22	220p polystyrene (2 off)
C27, C31, C39, C43	2µ2 radial elect., 50V (4 off)
C28, C40	1µ radial elect., 50V (2 off)
C30, C42	150p polystyrene (2 off)
C32, C44	100p polystyrene (2 off)
C34, C46	470n polyester (2 off)
C47, C51	330n polyester (2 off)
C48, C52	100n polyester (2 off)
C50, C54, C56, C57, C59, C60	100n ceramic (6 off)
C55, C58	1000µ radial elect., 25V (2 off)

Semiconductors

D1, D2	OA91 germanium signal diode (2 off)
D3 to D6	1N4148 silicon signal diode (4 off)
D7 to D14	1N4002 100V 1A rectifier diode (8 off)
IC1, IC3, IC6, IC9	TLE2027CP low noise op.amp (4 off)
IC2, IC4	NE5534AN low noise op.amp (2 off)
IC5, IC7, IC8, IC10, IC11	TL071CP bifet op.amp (5 off)
IC12, IC13	LM358N dual op.amp (2 off)
IC14, IC15	µA7812 12V 1A positive regulator (2 off)
TR1	BC549 *npn* transistor
TR2	BC559 *pnp* transistor

Miscellaneous

FS1, FS2	20mm 500mA quickblow fuse (2 off)
FS3	20mm 500mA anti-surge fuse
T1	record head transformer (see text and below)
T2	mains transformer, twin 12V 500mA secondaries
ME1, ME2	Twin 250µA VU meter (see text)
S1	d.p.d.t. min. toggle switch (see text)
S2	d.p.s.t. min. toggle switch
S3	d.p.d.t. min. toggle switch
S4	d.p.s.t. rotary mains switch
SK1, SK2	twin phono socket (2 off – see text)
SK3, SK4	3·5mm jack sockets (2 off – see text)

Printed circuit boards, available from the *EPE PCB Service*, codes 128 (Playback/PSU), 129 (Record); cassette mechanism with heads (see text); knob (5 off); case (see text); 20mm fuse-clip, p.c.b. mounting (2 off); 20mm fuseholder, panel mounting; 8-pin d.i.l. socket (13 off); multi-strand connecting wire; screened lead; mains lead and plug; solder, etc.

Materials for transformer T1: LA4345 pot core assembly, bobbin, fixing clips (2 off), 24 s.w.g. enamelled copper wire.

Note that the record/playback switching will probably require an additional 1N4148 diode, plus a 12V relay having a coil resistance of at least 185 ohms and with a minimum of three changeover contacts (see text).

Approx Cost Guidance Only **£68** **excl. cassette unit and case**

the extra voltage. There should be no problems with excessive current consumption, since 6V decks seem to consume only about 100mA to 200mA.

RECORD/PLAY SWITCHING

In the likely event that the cassette mechanism cannot provide sufficient contacts for the record/playback switching, a single set of normally open contacts on the deck are used to provide this switching via a relay. The relay coil is connected between the 0V and main 12V supply via the microswitch, and the relay will therefore be activated when the deck is set to the "record" mode (Fig. 7). A 1N4148 diode connected across the relay coil suppresses the high reverse voltage generated when the relay is switched off.

The relay must provide a minimum of three changeover contacts. RLA1 to RLA3 respectively replace switches S1c, S1a, and S1b. The relay coil should have a voltage rating of 12V and a resistance of about 185 ohms or more. However, 12V relays having three or four sets of changeover contacts are relatively rare these days, but suitable "Continental" style relays can still be obtained new, and are frequently available on the surplus market.

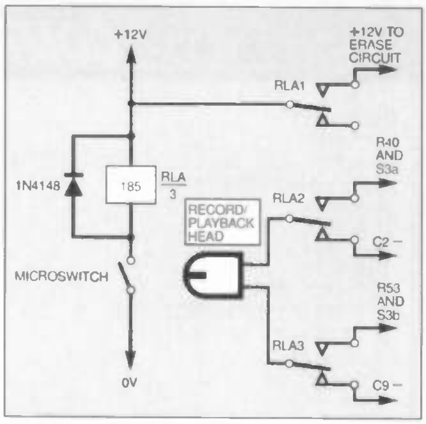


Fig. 7. Using a relay to provide the record/playback switching.

Alternatively, two relays having coil resistances of about 300 ohms or more and two sets of changeover contacts will provide four sets of changeover contacts. The two relay coils should be wired in parallel. Two 6V relays having coil resistances of about 80 ohms or more and their coils wired in series represent another way of providing sufficient contacts. Unless a suitable relay can be found on the surplus market, the twin relay approach might actually be cheaper.

The record/replay switching shown in Fig. 7 represents a minimalist approach to the problem. In practice it might be better to include additional switching, such as removing power to the record circuits except when recording. This eliminates the possibility of breakthrough from the recording circuits to the playback amplifier.

A slight problem with this extra switching is that it makes it necessary to record onto a tape in order to set the recording level controls. A bypass switch would

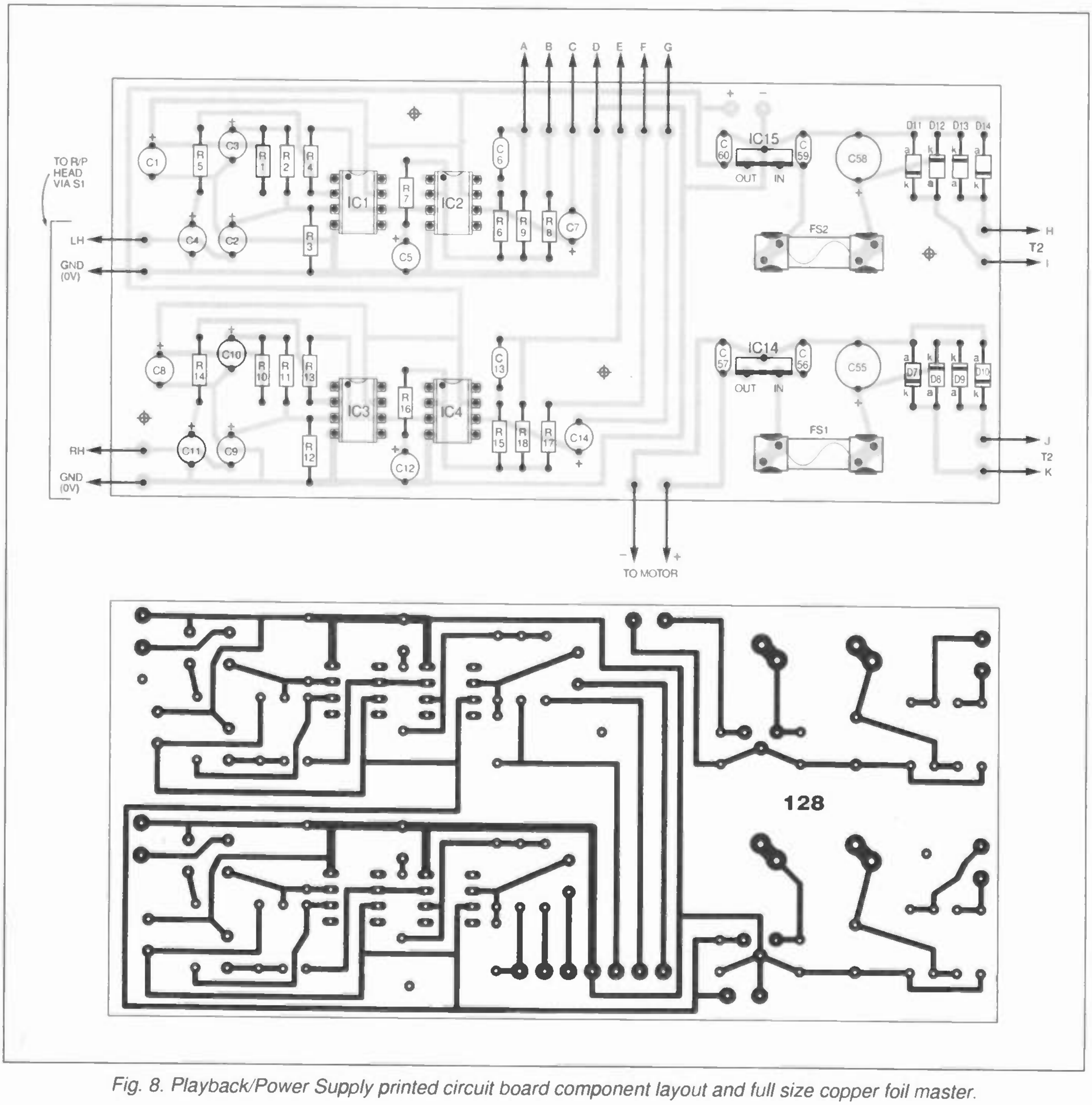


Fig. 8. Playback/Power Supply printed circuit board component layout and full size copper foil master.

enable the recording level to be set prior to actually recording anything. Also, many cassette mechanisms have a "pause" button. Selecting "play/record" and then "pause" enables the recording level to be set. The "pause" button is then pressed again in order to start recording.

CASE SELECTION

As already pointed out, the mechanical side of construction must be varied to suit the particular cassette mechanism used. The case must be quite large in order to accommodate all the components, with a minimum width of about 300 millimetres being required.

As the unit is *mains* powered the case should be of all-metal construction and be "earthed" to the mains Earth lead. The lid of the case must be a screw fitting type, and not a clip-on type which would permit easy access to the dangerous mains wiring.

Most modern relays have no provision for chassis mounting, which makes it potentially difficult to mount the record/playback relay. It should possible to reliably mount a cased relay on the base panel of the case using a high quality adhesive, such as an epoxy type or a "Superglue".

PLAYBACK BOARD

The component layout and actual size foil track pattern for the Playback and Power Supplies board (p.c.b.) are shown in Fig. 8. This board is available from the *EPE PCB Service*, code 128.

None of the integrated circuits used in this project are static-sensitive, but it is still advisable to fit all the d.i.l. (dual-in-line) types in holders. Fit single-sided terminal pins at the points where the connections to the controls, sockets, etc. will eventually be made.

IC14 and IC15 are mounted on the board vertically. IC15 should be fitted with a small heatsink if the current consumption of the electronics and relay is more than about 150mA. It is unlikely that IC14 will require a heatsink unless it is an 8V regulator used to power a 6V motor. It would then be best to play safe and fit it with a small heatsink. For either regulator any small bolt-on heatsink for TO220 devices should be more than adequate. In fact, a small "U" shaped piece of 18 s.w.g. aluminium should suffice.

Fuses FS1 and FS2 are normal 20mm "quick-blow" types, mounted on the board via a pair of fuse-clips. Be careful to fit capacitors C55, C58, and the eight rectifier diodes (D7 to D14) with the correct polarity. Errors here could result in costly damage, and could be dangerous.

Capacitors C6 and C13 must be printed circuit mounting types having 0·3 inch (7·5mm) lead spacing if they are to fit easily onto the board. Capacitors C56, C57, C59 and C60 must be disc ceramic types, or some other form of miniature ceramic capacitor. The electrolytics must all be reasonably small radial (vertical mounting) types if they are to fit neatly into place.

WIRING

The wiring associated with the playback and power supply board is shown in Fig. 9, which should be used in conjunction with Fig. 8. A solder tag fitted on one of transformer T2's mounting bolts provides a reliable means of connecting the mains Earth lead to the case. It is advisable to take a lead from this solder tag to the chassis of the cassette mechanism, to make absolutely certain that it is reliably earthed.

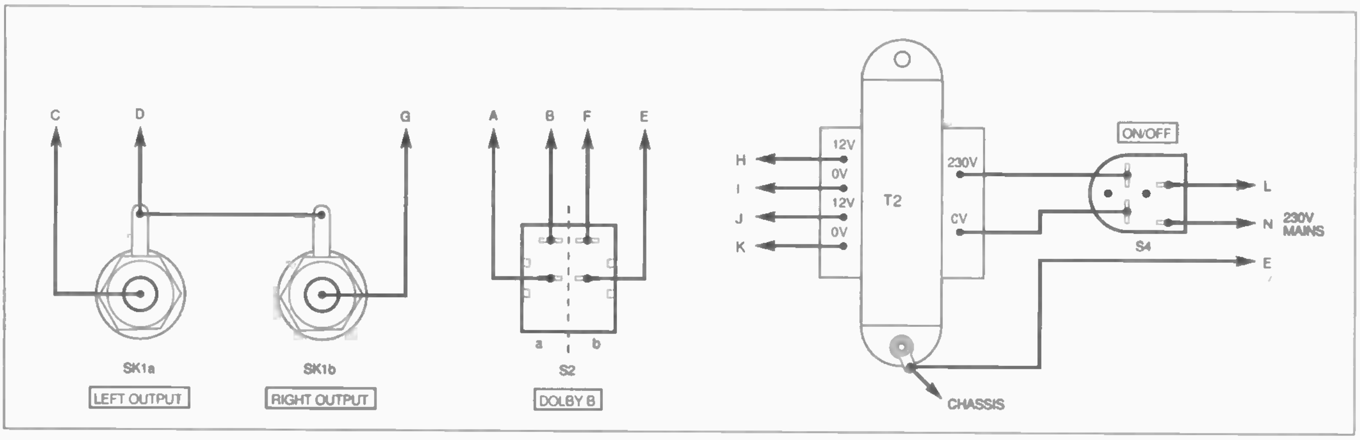


Fig. 9. Wiring details for the playback/power supply off-board components. Leads designated with letters A to K join up with identical points on the p.c.b. in Fig. 8.

It should be possible to customise a ready-made case to suit practically any cassette mechanism, but it is probably best to settle for a relatively simple case. It will almost certainly be necessary to undertake a fair amount of cutting and filing in order to fit the cassette mechanism into the case. This is likely to be easier with a simple aluminium case than a fancy aluminium and steel type.

Timber end pieces (cheeks), etc. can be used to give a more hi-fi style appearance if desired. Ideally the case would be custom made to fit everything, but this is only a practical proposition for those who possess the requisite skills and have access to suitable tools.

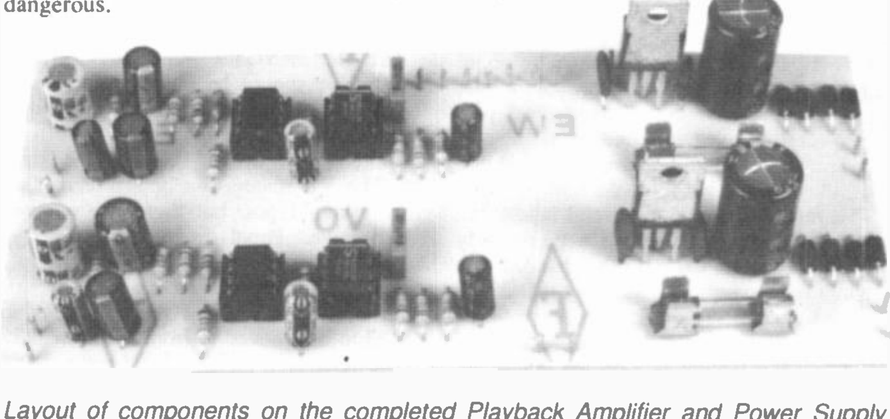
It is normal for a cassette mechanism to be mounted in the case via some form of flexible mounting to prevent the mechanism from spreading noisy vibrations through the case. For a home-constructed recorder it should be possible to improvise a suitable mounting based on some rubber grommets and washers. Without some form of vibration absorbing mounting there will almost certainly be a high level of mechanical noise from the unit.

CASE LAYOUT

The general layout of the unit is not too critical in most respects, but it is advisable to keep transformer T2 and the mains wiring as far away as possible from the tape heads and the input wiring to the recording and playback amplifiers.

Socket SK1 is shown as a twin phono socket in Fig. 10, but it can be a 5-way DIN type, or any audio connector that fits in well with your audio gear. As the output signal is at a fairly high level and a low impedance it is not essential to use screened leads to make the connections to this socket.

The wiring to switch S2 does not have to be screened, but this wiring must be reasonably short. The gain of the playback amplifier is very high at low frequencies, making it susceptible to stray pick up of mains "hum". It is therefore essential that all the input wiring is properly screened, including the wiring from the record/playback switch to the tape head.



Layout of components on the completed Playback Amplifier and Power Supply board. Only this p.c.b. is needed for the Playback only version.

RECORD/ERASE BOARD

The component layout and actual size foil track master for the record amplifier/erase oscillator board appears in Fig. 10. This board is available from the *EPE PCB Service*, code 129.

Construction of this board follows along much the same lines as construction of the playback board. However, there are a few additional points to note.

The seven preset potentiometers must be miniature horizontal mounting types (open or closed construction) if they are to fit onto the board properly. Do not overlook the three short link-wires.

Diodes D1 and D2 are germanium and are more vulnerable to heat damage than silicon types such as the 1N4148; extra care needs to be taken when soldering them into place. It should not be necessary to use a heatshunt, but do not apply the bit to each soldered joint for any longer than is really necessary.

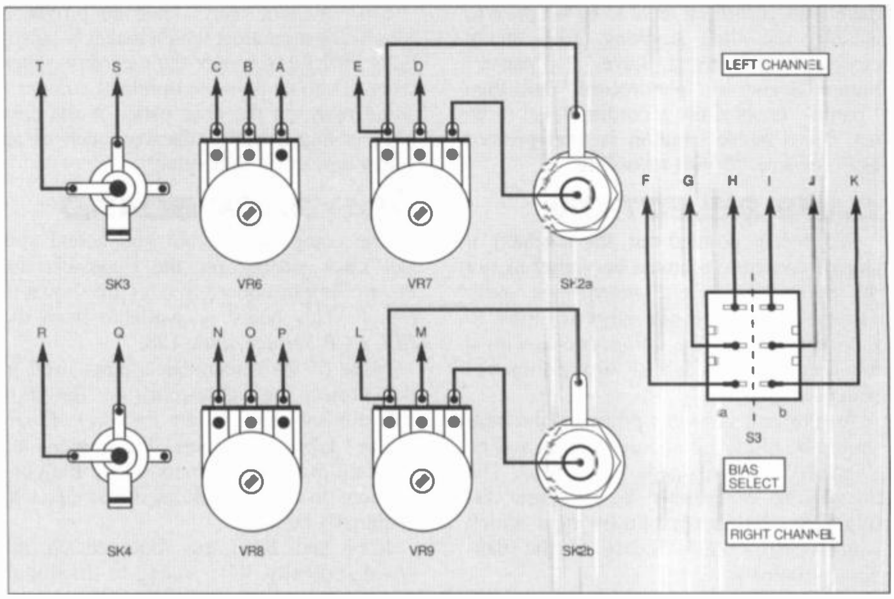


Fig. 11. Off-board wiring details for the Record/Erase components. Leads designated with letters A to T join up with identical points on the p.c.b. in Fig. 10.

OSCILLATOR COIL

Suitable transformers and coils for use in tape erase oscillators do not seem to be available any more. Transformer T1 must therefore be home constructed, and it is based on an LA4345 ferrite pot core assembly. In addition to the two-section pot core, a bobbin and two fixing clips are required. Some 24s.w.g. (0·056mm diameter) enamelled copper wire is also needed.

There is a pair of printed circuit mounting pins at each end of the bobbin. One pair is used for the primary winding, and the other for the secondary. The bobbin is symmetrical, and the phasing of the windings is unimportant. Therefore, it does not matter which pair is used for the primary and which is used for the secondary, or which pin in each pair is used for the start of the winding. The only important point is that each winding must *start* and finish at the same *pair* of pins.

Starting with the primary, use the blade of a penknife or a small file to remove a small amount of insulation from one end of the wire. Then "tin" the bare end of the wire with solder, and do the same to the top of each pin on the bobbin. Solder the end of the wire to the top of one pin, and then wind 10 turns of wire neatly and tightly around the bobbin using a single layer of closely spaced turns.

To complete the primary winding, cut the wire to length, remove a small amount of insulation from the end of the wire, "tin" it with solder, and then solder it to the top of the second pin on the primary side of the bobbin. Use a small blob of paint on the bobbin, near the appropriate pair of pins, to indicate which two pins connect to the primary winding.

The secondary winding is produced in a similar fashion, but it has 55 turns of wire. This must be wound in several layers, but it is not essential to make a particularly neat job of this. On the other hand, if the winding is too rough it is likely that it will be too large, making it impossible to fit the bobbin into the pot core.

Once the bobbin is installed inside the two halves of the pot core, use the two metal clips to clamp the two sections of the core together. The pot cores are made from a brittle ferrite material, so treat them with due care. Dropping them or even squeezing them too hard when fitting the clips can result in serious damage to the cores.

The completed transformer is mounted on the board and then soldered in place, making quite sure that it is fitted on the board the right way round.

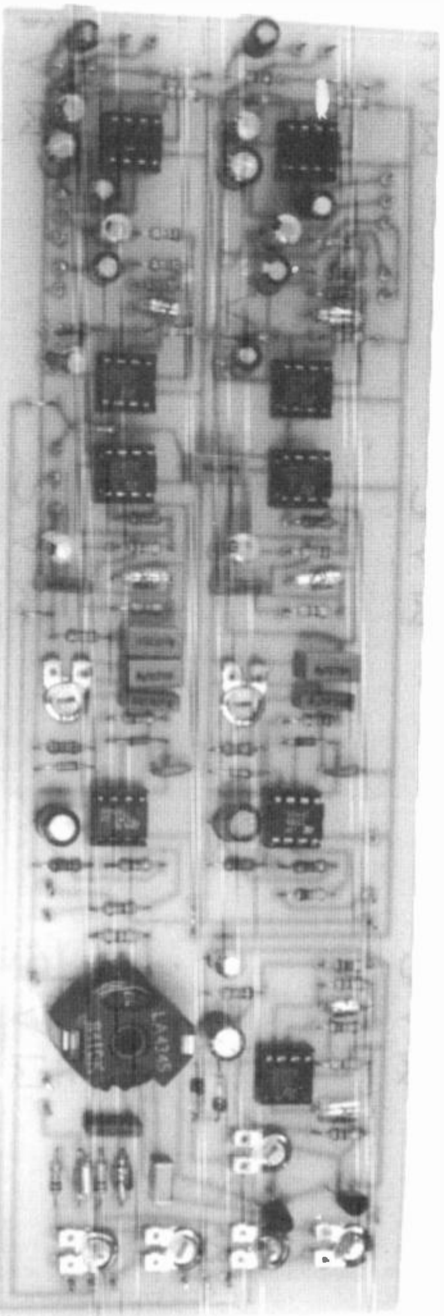
WIRING

Wiring associated with the Playback and Erase Oscillator board is shown in Fig. 11. A twin phono socket is used at the line inputs, but again, this can be replaced with a DIN type or any audio socket that fits in well with your audio equipment. The wiring to socket SK2, switch S3, and the four potentiometers does not have to be screened provided it is all kept reasonably short.

On the prototype, ordinary rotary potentiometers are used for the recording level controls. Many constructors will probably prefer to use slider types, which make it easier to adjust the left and right hand channels in unison. Do not overlook the possibility of using dual concentric rotary potentiometers, which also make it easy to adjust the two stereo channels in unison, and do not have any awkward mounting requirements.

Sockets SK3 and SK4 are 3·5mm jack types, which match the plugs fitted to most low impedance dynamic microphones. The higher quality dynamic microphones and electret types are often fitted with standard (0·25inch) jack plugs. Obviously SK3 and SK4 should be changed to standard jack sockets where appropriate. Screened leads *must* be used to connect them to the printed circuit board.

The VU meters can be standard 60mm by 40mm types, but these are relatively expensive. Panel meters of this type have the required full scale sensitivity of 250μA, but seem to have a built-in series resistor. This requires resistors R58 and R63 to be reduced to from 10kΩ to 3k3Ω. The relatively inexpensive Maplin "Dual VU Meter" is used on the prototype, and this has been found to give good results despite its low cost.



The finished Record/Erase p.c.b.

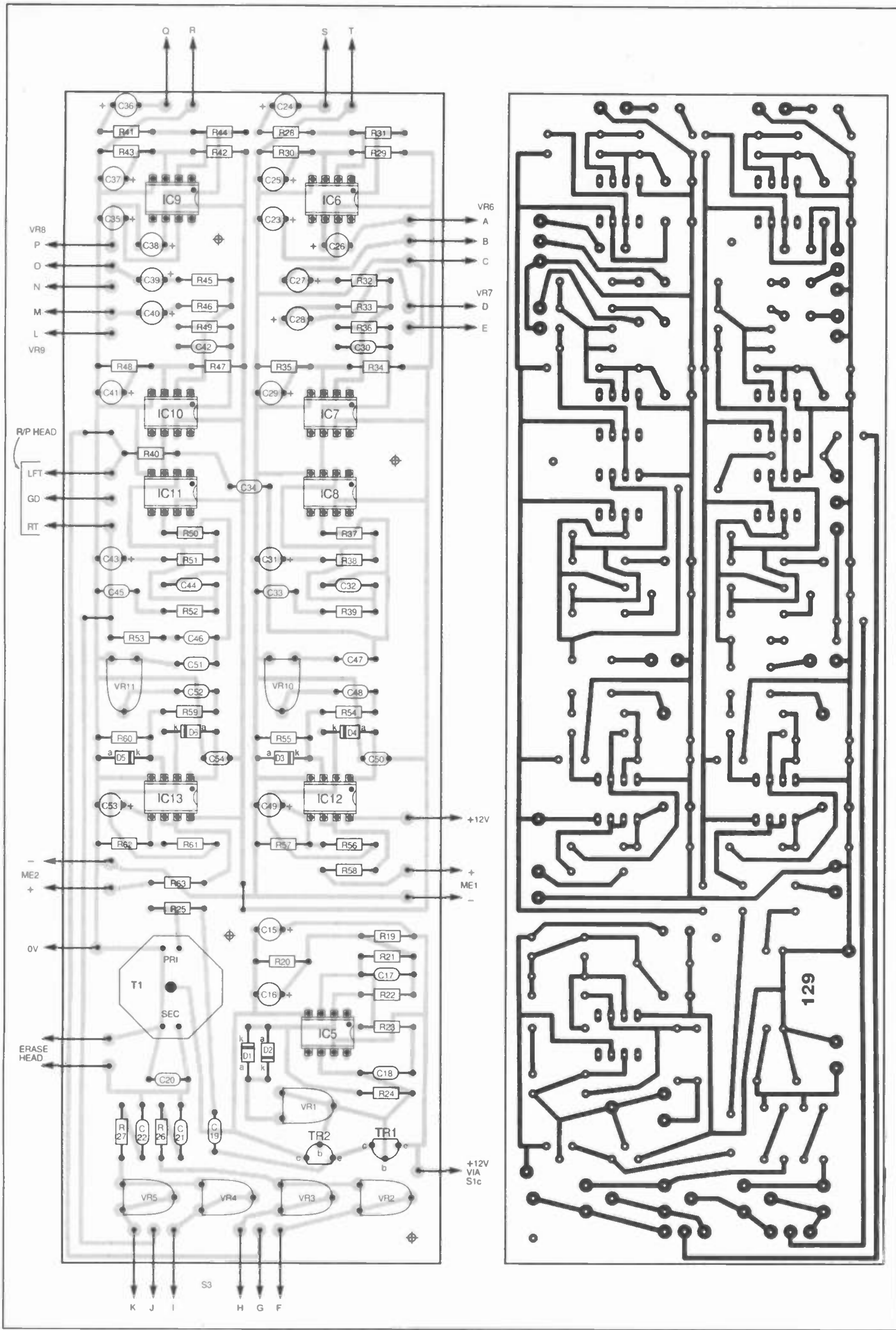
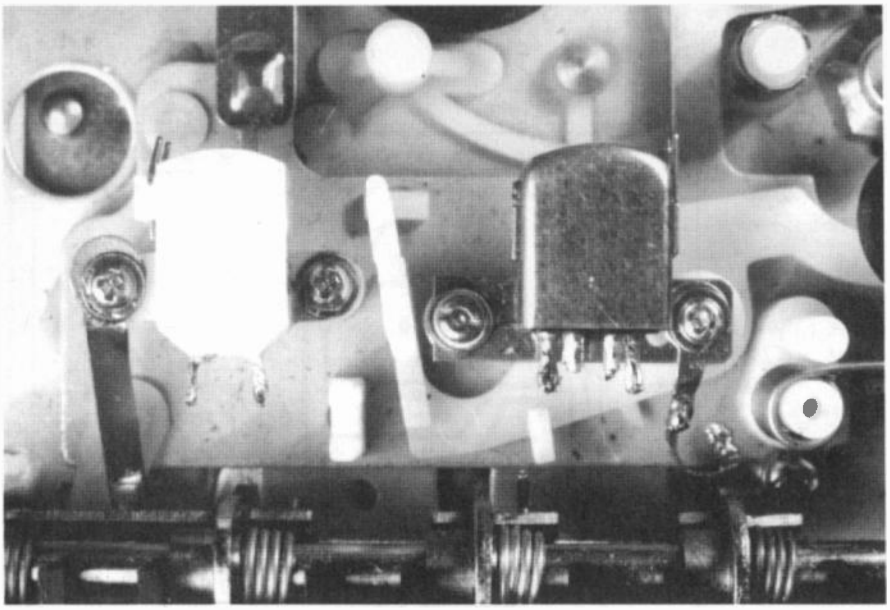


Fig. 10. Record/Erase printed circuit board component layout and full size copper foil master.



The replay head is on the right. The mounting screw on the left provides the azimuth adjustment.

AZIMUTH ADJUSTMENT

It is advisable to initially check the unit in the playback mode using a test recording of some music made using another recorder, and not using your favourite pre-recorded cassette. Then, if the record/playback switching is not working properly, you will not accidentally erase anything important!

The unit should provide a strong output signal of reasonable quality if the playback mode is working properly. However, the signal may be lacking in treble due to an error in the azimuth adjustment of the record/playback head.

For the head to scan the tape tracks properly it is essential for it to be at the correct height. If it is slightly too high or too low, part of each track will be missed, and a lack of treble response will result.

Tape heads are normally mounted by two screws, and the azimuth setting is normally controlled by the left-hand screw when looking onto the rear of the head. To set the azimuth correctly, play a pre-recorded tape through the unit, and then set the azimuth adjustment screw for maximum treble response.

OUTPUT LEVEL

In order to get good results when recording it is necessary to set a suitable output level from the erase oscillator, and then set appropriate bias levels. If an oscilloscope is available, use it to monitor the signal across capacitor C20. With preset VR1 set close to maximum resistance (set well in a counter-clockwise direction) a strong sinewave signal at a little over 40V peak-to-peak should be produced.

By advancing VR1 in a clockwise direction it should be possible to reduce the amplitude of the output signal, and the quality of the waveform should also improve. Good results should be obtained with the signal level at around 30V to 35V peak-to-peak.

Finding a suitable setting for VR1 becomes a matter of trial and error if access to an oscilloscope is not possible. Setting VR1 well in a clockwise direction gives an improved waveshape, but if it is adjusted too far the oscillations will not be strong enough, or may even cease altogether. It is a matter of finding the most clockwise setting that gives an adequate degree of erasure.

BIAS LEVEL

With the bias level presets adjusted to a roughly central setting, the recording section of the circuit should work quite well. Finding the optimum settings without the aid of any test equipment is just a matter of making some test recordings at various bias levels, and using subjective assessment to determine the bias level that gives the best overall frequency response.

If suitable test gear is available, make some frequency response tests at a recording level of about −20dB to determine the bias settings that give the flattest overall frequency responses. The easiest way to do this is to record a square wave signal at a frequency of around 50Hz to 100Hz. The best bias settings are the ones which give a squarewave output signal that is free from any major overshoot, or other serious irregularities.

Of course, the high frequency limit of the system will produce some rounding of the waveform, and the low frequency limitations will produce the usual sloping horizontals on the waveform. Chromium dioxide tapes need a higher bias level (the presets set further in a counter-clockwise direction) than normal ferric types.

Using an excessive recording level produces very soft clipping on the played-back signal. Consequently, there is no rigidly defined maximum recording level. Even if some audio test gear is available, it is probably best to use subjective assessment and some test recordings to determine the best settings for the recording meter sensitivity controls (VR10 and VR11). The sensitivity should be set quite high if low distortion is deemed to be of paramount importance. Set the sensitivity lower (set VR10 and VR11 further in a clockwise direction) if a better signal-to-noise ratio but higher maximum distortion are preferred.

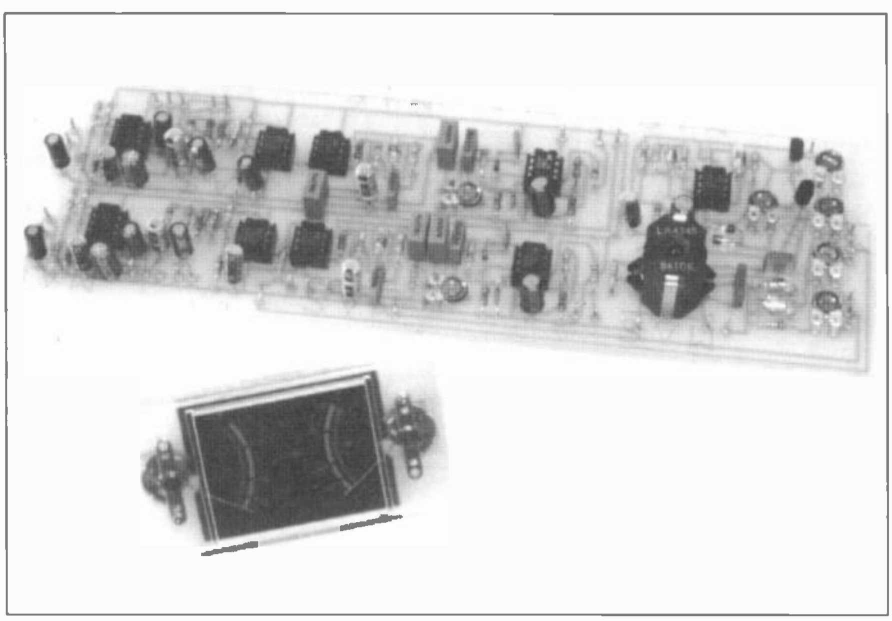
RESULTS

The results obtained from these circuits depend to a significant extent on the particular cassette mechanism and heads used. The quality of the tapes used is also a significant factor. Some cassette mechanisms give much lower "wow and flutter" levels than others, and some tape heads seem to give more treble and less noise than others.

The prototype equipment has been tried with half a dozen cassette mechanisms (two of which are playback-only), and all gave respectable results. Using good quality tape and heads plus one of the better cassette mechanisms it is possible to obtain some quite impressive results, even though the unit lacks any form of noise reduction circuitry. A signal-to-noise ratio of over 60dB can be achieved.

However, be prepared to spend some time experimenting with different bias levels, etc. Some "tweaking" of the playback equalisation values might also be worthwhile for perfectionists. □

Completed Record/Erase board together with "stereo" VU meter.



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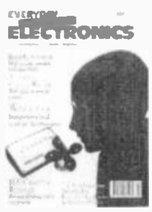

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NEXT MONTH

A WORLD FIRST

THEREMIN MIDI/CV INTERFACE

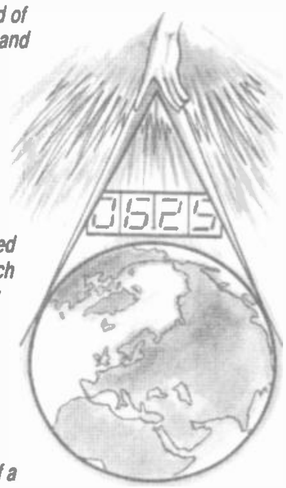
During his incredible life the visionary Leon Theremin said that it would one day be possible to play any musical instrument via the Theremin, which he first demonstrated in 1920. Sadly Leon Theremin died just a couple of years before his prophecy was fulfilled in the MCV1a Theremin MIDI/CV Interface.

The MCV1a is a pitch/amplitude to MIDI and CV interface. There are 128 user patches which can be loaded from the front panel, footswitch or remotely via the MIDI program change message; each patch contains detailed setup parameters including octave range, pitch bend range, amplitude sensitivity, velocity sensitivity, volume sensitivity, tone offset, program change and more!

Some of the main features are:

- *Interface directly with any Theremin*
- *128 user programmable patches*
- *Real-time pitch readout*
- *Eight octaves of pitch tracking through 14-bits of pitch bend data*
- *Control over octave range down to one semitone allowing glissando playing*
- *Auto octave switching with control over octave of sequences with a Theremin*
- *Built in MIDI merge facility to allow control of sequences with a Theremin*
- *External footswitch connection for Hold mode*
- *CV voltage range and scaling software adjustable*
- *Two 1V/octave voltage outputs with Gate and Trigger 5/15V and switch definable*

EARTH RESISTIVITY METER



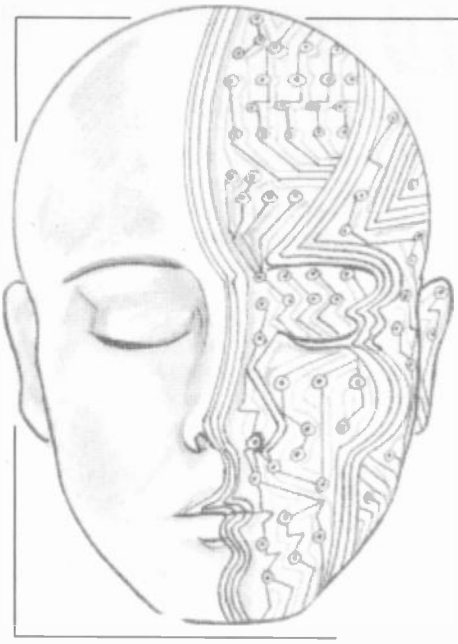
Resistivity surveying is a method of detecting subterranean features and has been an investigative technique of archaeologists for many years. Archaeological features can often be detected when buried about one metre under the present ground level. Natural features such as gravel or peat beds buried under silt can be detected at much greater depths. The same survey will detect both natural and archaeological features. In general, the former tend to have ill defined "soft" edges whilst the latter consist of geometric "man made" shapes, i.e. if it "looks like" the outline of a building, it probably is!

This article describes the principles of resistivity surveying and goes on to present full constructional details of an Earth Resistivity Meter.

MAINS-FAILURE WARNING

This device will be of interest to anyone wishing to guard against mains appliances being switched off accidentally. Fridges and freezers are obvious targets but some readers will wish to protect such items as aquarium and reptile heaters, greenhouse equipment and emergency water pumps. It may also have applications with medical and scientific apparatus.

If the unit being monitored is disconnected from the mains, either by being switched off, or because of a blown fuse, tripped RCD or simply mains failure, then an alarm will sound either next to the appliance or remotely as required.



Our regular round-up of readers' own circuits. We pay between £10 and £50 for all material published, depending on length and technical merit. We're looking for novel applications and circuit tips, not simply mechanical or electrical ideas. Ideas *must be the reader's own work* and **not have been submitted for publication elsewhere.** The circuits shown have NOT been proven by us. *Ingenuity Unlimited* is open to ALL abilities, but items for consideration in this column should preferably be typed or word-processed, with a brief circuit description showing all relevant component values. Please draw all circuit schematics as clearly as possible.

Send your circuit ideas to: Alan Winstanley, *Ingenuity Unlimited*, Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset BH21 1PF. They could earn you some real cash!

Mains Appliance Timer – cooked up in the kitchen!

THIS design makes use of a low-cost digital kitchen timer to control mains appliances. No modification is needed to the timer, the only requirement being that it must beep both when the start button is pressed, *and* when the period has expired.

The circuit diagram for the Mains Appliance Timer shown in Fig. 1 detects the supply current flowing through the timer, and drives an external relay circuit which operates mains loads for a period set by the kitchen timer.

A low-voltage supply is formed by transistors TR1 and TR2, being a ring-of-two constant current source adapted to provide about 1·5V at TR1 emitter (e). This powers the timer. The supply for the complete circuit is mains derived via transformer T1 and regulated down to 12V by IC4.

At power on, capacitor C3 provides a positive pulse which sets IC3a (pin 8), one half of a dual D-type flip-flop. Output QA (pin 13) goes high which resets IC3b so that QB (pin 1) is low. Transistors TR4 and TR5 are off and so the relay RLA does not operate. However, transistor TR3 is driven on which illuminates the green l.e.d. D1 to indicate reset.

The digital timer can now be set to the desired duration. Then switch S1 is pressed, which resets IC3a, QA goes low which enables IC3b.

On pressing the timer's "Start" button, the increase in its supply current caused by the beep rises from a few microamps to 5mA or more. The voltage across resistor R5 rises and comparator IC1, whose threshold is set by resistors R4 and R6, will output a brief positive pulse.

This is cleaned up by the monostable formed from IC2a and IC2b, and clocks IC3b. Output QB (pin 1) now goes high and powers the relay via the Darlington transistor pair. Red l.e.d. D2 illuminates to indicate timing is in progress.

At the end of the period, the first beep clocks IC3b again. Output $\overline{QB}$ (pin 2) goes high to clock IC3a (pin 11); QA goes high and resets IC3b so that the relay switches out.

B. J. Taylor, Rickmansworth, Herts.

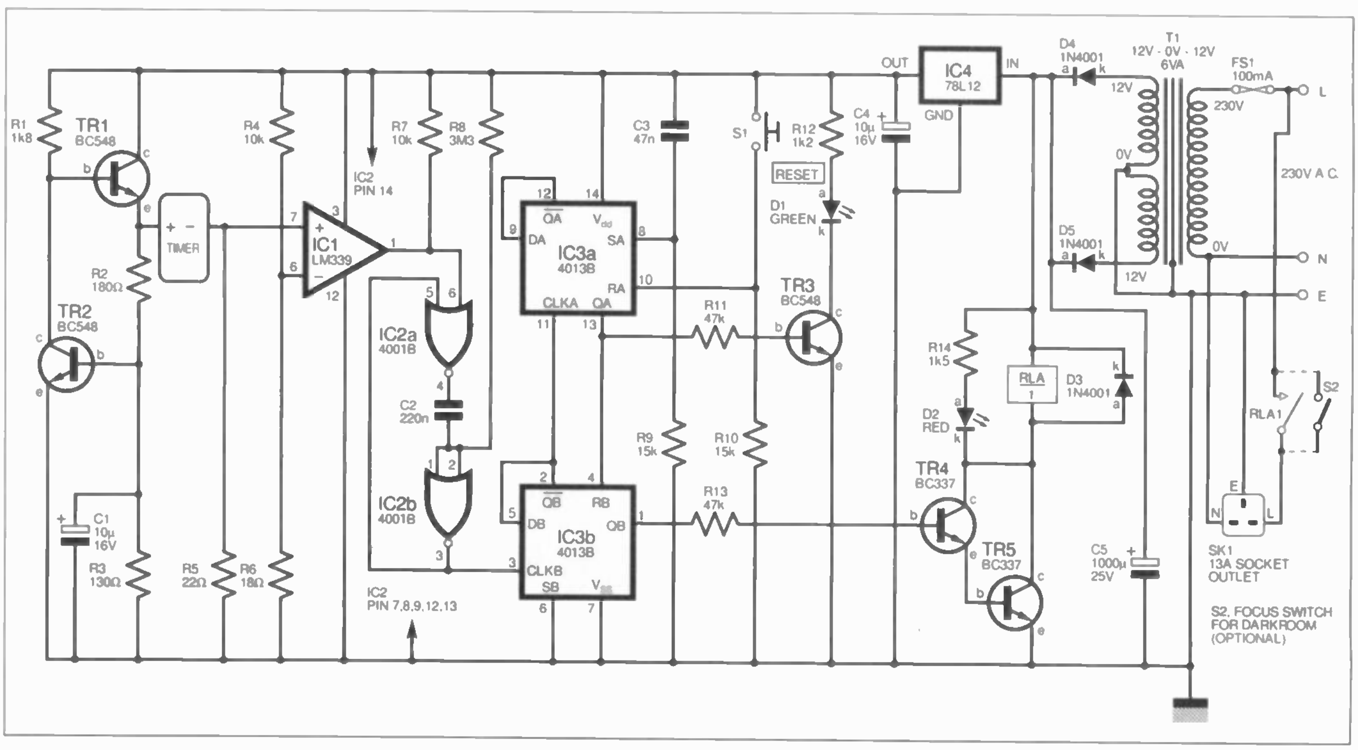


Fig. 1. Circuit diagram of the Mains Appliance Timer.

Christmas Lights Dimmer and Life Extender

My solution to the perennial problem of extending the life of Christmas Lights is shown in Fig. 2. It is based on a standard diac/triac dimmer configuration which has been optimised for this application. Cheap dimmers omit R3, R4 and C2 which is why they have the irritating habit of not turning on until the control is half-way up, and then coming on comparatively brightly.

The values of resistors R1 and R5 were found empirically, and also determined the value I eventually selected for control potentiometer VR1. Resistor R2 is however optional and was only included to help discharge the capacitors quickly.

All capacitors are 250V a.c. X2 rated ***(this is very important)***, all resistors are 500V working voltage, and the triac CSR1 was chosen for its low holding current so that it would function with small loads. Note that VR1 is fitted with a double-pole mains switch for complete isolation.

Even with only one 20-lamp string plugged in (22 watts) control is very smooth with barely any trace of hysteresis. It can be built safely on a piece of matrix board, wired point-to-point, provided it is mounted in a ***completely insulated plastic case*** and that no external components (i.e. S1 and VR1) are metal. *(Do not build this circuit if you do not understand the safety requirements – Ed.)*

B. J. Taylor,
Rickmansworth, Herts.

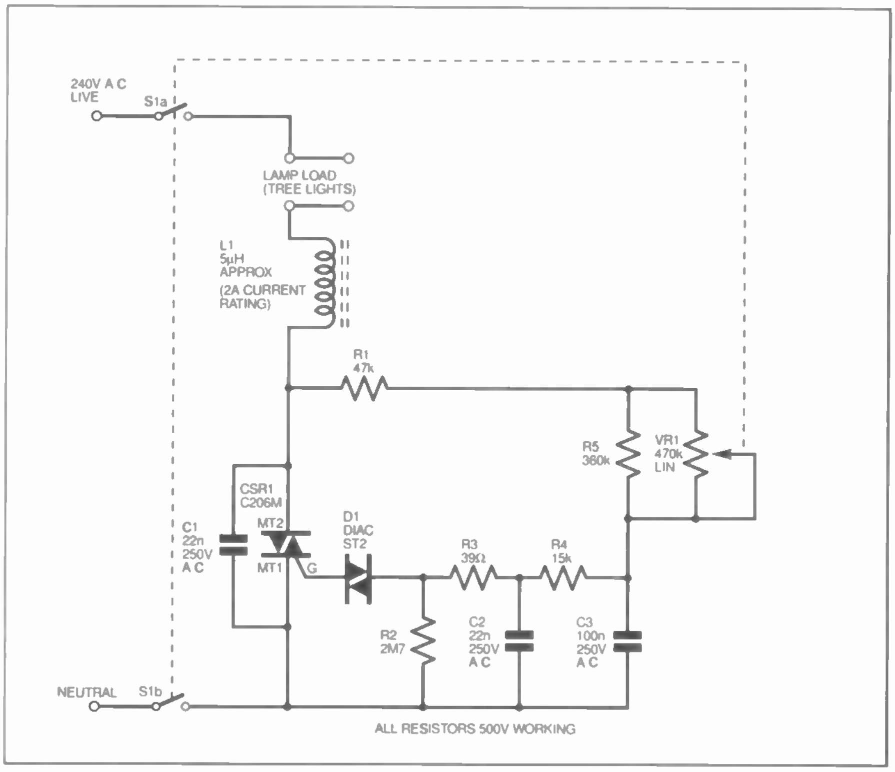


Fig. 2. Circuit diagram of the Christmas Lights Dimmer and Life Extender.

SHOP TALK
with David Barrington

Vari-Colour Christmas Tree Lights

Most of the components, or substitutes, needed to put together the *Vari-Colour Christmas Tree Lights* should be readily available items from our advertisers. The tri-colour l.e.d.s. should be the "high brightness" type.

The l.e.d.s used in the model came from **Maplin**, code CJ53H. As the red sections have a lower turn-on voltage than the green, it is essential to drive *all* the red section from one output and green from the other. Do *NOT* attempt to try "mixed" operation.

A mains transformer with twin secondary windings rated at 9V 333mA each, and wired in parallel, was used in the prototype. This effectively gives the required "single" winding of 9V 666mA as specified. The transformer was also purchased from the above company, code DH24B.

For reasons of personal safety this project *must* be housed in a ***metal*** box, with a screw fitting lid and be soundly "earthed" to the mains Earth lead.

PIC Digital/Analogue Tachometer

Apart, of course, from a ready-programmed PIC 16C54XT chip, most components called-up for the *PIC Digital/Analogue Tachometer* should be carried by most of our component advertisers. The 4MHz crystal certainly seems to be widely available.

The small ABS plastic case used in the model was obtained from **Maplin** (code KC93B), it was chosen for its small size and because the p.c.b. will fit snugly inside. They also list a suitable dual-digit 7-segment l.e.d. display, code BY68Y. This display must be the common *cathode* type.

The 10-segment bargraph display should not be a problem and is widely listed for about £2·50, in red or green.

Special arrangements have been made with **Magenta Electronics** (***Tel: 01283 565435***) to supply a ready-programmed PIC 16C54XT (or 16C84XT) microcontroller for the sum of £15 all inclusive. (Overseas readers should add £2 to their order). All orders should be sent to: **Magenta Electronics, 135 Hunter Street, Burton-on-Trent, Staffs DE14 2ST.**

The software source code is obtainable on a 3·5in disk from the Editorial Offices for the sum of £2.50 (Overseas: £3·10 surface; £4·10 airmail, see page 891. Alternatively, Internet users can down-load it *free* from our ftp site: **ftp://ftp.epemag.wimborne.co.uk**

The printed circuit board is obtainable from the *EPE PCB Service*, code 127 (see page 945).

Stereo Cassette Recorders

Before tackling the *Stereo Cassette Recorder*, it should be noted that although the circuits provided have been tried and fully tested they are primarily aimed at the experienced constructor who likes to experiment. It is not a project for beginners.

For superior performance it is best to stick with the TL2027CP precision op.amp where specified. If local sourcing proves a problem, it is currently listed by **Maplin**, code CP86T. Using inexpensive devices, such as the 741C, LF351N etc. is not to be recommended.

You could find the erase oscillator ferrite LA4345 pot core and assembly a little troublesome to find locally. You could try **Maplin**, **Cirkit**, or **Electrovalue** who carry a good range of ferrite products.

The choice of tape mechanism is left to individual requirements; just Playback or full Record/Playback operation. However, **Display Electronics** (excellent results reports the designer) and **Bull Electrical** (untried) have stocks of cassette tape mechanisms. For replacement heads you could try contacting **Hart Electronics** (***Tel: 01691 652894***).

The two printed circuit boards are available from the *EPE PCB Service*, codes 128 (Playback/PSU) and 129 (Rec/Erase) see page 945.

EPE Elysian Theremin

Some of the components needed to put together the *EPE Elysian Theremin* could be described as being special items. Most of these are the "hardware" requirements.

As far as the "active" components go, items such as the diodes and i.c.s. should be stocked by most of our component advertisers. The switched jack sockets, SCJ-0639, are special commercial types used in sound studios and can be purchased from the author, **Jake Rotham**, who specialises in audio work. The nearest we have come to these are the **Maplin** "PCB sockets", with switched contacts.

The designer, Jake Rothman, has put together a range of kit options, including hardware, so that readers can select their own requirements. For further information write to him at: **93 St. Johns Road, Frome, Somerset, BA11 2BE.** ***Also see his advertisement.***

Some readers have experienced difficulties in obtaining the specified Schottky diode, we understand from the designer that BAT42 and BAT85 types will work equally as well in this circuit.

The EPE Elysian Theremin double-sided, plated-through-hole, printed circuit board is available from the *EPE PCB Service*, code 121 (see page 945).

PLEASE TAKE NOTE

10MHz Function Generator ***(Aug '96)***

Pages 760/61, Fig. 4 and Fig. 5. It has been pointed out that there is an error on the main p.c.b. (code 118). IC2 pin 1 has been incorrectly connected to pin 7 and capacitor C20, which will cause the circuit to malfunction.

There is a choice of three simple corrective actions:

1. Insert IC2 with pin 1 bent out so that it does not enter the i.c. socket.
2. Cut off pin 1 from IC2 or remove the pin from its socket.
3. Cut the track between IC2 pin 1 and pin 7, and also cut the track between pin 1 and C20. Then solder a wire between C20 and IC2 pin 7.

The p.c.b. available from the *EPE PCB Service* has now been corrected.

FOX REPORT

by Barry Fox

Hot Reception

London radio listeners were up in arms when the Radio Authority shut down *LBC*, and gave the licence to a rival company. Market research had shown that even after a year of the new station, most Londoner's were still calling it LBC.

Now, after a lot of corporate wheeling and dealing, which I do not pretend to understand, the new station has gone back to using the LBC name and putting on similar programmes. The difference is that LBC used to broadcast the same programmes on its f.m. frequency (97·3MHz) and its a.m. frequency (1152kHz). Now the station is split, with news on 97·3 f.m. and LBC chat and phone-ins on 1152 a.m.

Listeners continually complain about poor reception, especially in the South London area. The signal from Saffron Green, on the A1 north of London is swamped by the Romanian station *Cluj* which bounces off the upper atmosphere to cause serious interference.

This is not surprising, the Romanian transmitter is rated at 950 kilowatts, compared to LBC's London transmitter which is rated at 23·5 kilowatts. There are also several other British ILR (independent local radio) stations on 1152kHz, for instance at Norwich and Birmingham and a Spanish station *Larida* running at 10 kilowatts. None of them have a hope against the monster *Cluj*.

Recently a listener phoned to say he was getting 1152 a.m. loud and clear from Bognor on the South Coast. Nonsense we said, it must a freak "sky wave" reflection. No, he insisted, it was routine, which suggests that the signal is coming by "ground wave".

I checked it out, by driving up and down the A259 road in the area of Bognor. The caller was right. 1152 came in clear as a bell throughout the day, and was even there some of the time after dark.

Some listeners have reported clear reception on French roads down from Calais. Someone else was getting the station in Paris.

Black Art

I asked NTL, who provide LBC's transmitters, what was going on. But NTL's spokesman seemed completely uninterested. "It's not that unusual", he said. "I am not an expert so I don't know why. Try the Radio Authority".

I tried the Radio Authority (RA) and immediately got the kind of interest I had expected from NTL. "I'd have said it was nonsense too", admitted an RA engineer, "but MF reception is a black art which noone fully understands".

The RA had two theories why listeners along the South Coast of England, and even over to France, could be hearing a London station which is hard to receive in South London.

In city areas there are a lot of steel buildings, and structures such as railway lines and gasometers which "steal" the signal by earthing it. In country areas there is far less steel, so radio aerials have a better chance. Likewise, of course, radio waves have a clear passage over the English Channel.

Ground conductivity also plays a part. The amount of moisture in the soil, and the ferrous content can affect propagation of the signal over the ground. Where there is a boundary between areas of high and low conductivity there may be less attenuation, so an apparent rise in gain. The moisture content depends on the height of the water table, which varies with rainfall.

The stronger the ground wave signal which is coming direct from the transmitter, the better it can withstand a reflective sky wave coming in from a distant station.

As one RA engineer explained, "I am a Celtic football fan, and when I lived in Hampshire I used to regularly listen to their matches by ground wave from Scotland on a Saturday afternoon. But at around 5 o'clock the sky wave interference started coming in, so I never heard the results".

I am still astonished by the lack of interest shown by NTL in a phenomenon which leaves people getting better reception from NTL's London transmitters in France than South London.

Last Chance Replicas

In the fifties there were two big names in American hi-fi, McIntosh and Marantz. Both made high quality valve amplifiers. Marantz is now owned by Philips and Product Manager Ken Ishiwata has gone back to basics. He has launched accurate replicas of the three most famous valve products made by Marantz, the Model 7, 8 and 9 pre- and power amplifiers first produced between 1959 and 1961.

Marantz went back to the original design drawings used in the USA and contacted the original component suppliers. Around 80 per cent could still supply.

The main difficulty was sourcing the valves. These come from the Golden Dragon Company in China, and all have to be checked on arrival; 90 per cent are sent back as below standard.

The new amplifiers cost between £3,000 and £4,500. Marantz already has several thousand firm orders from Japan, Taiwan and Korea. Because the original factory in the US is no longer available, the company has subcontracted manufacture to Vax in Florida.

"This is the last chance to build a genuine replica of an original valve amplifier", says Ken Ishiwata. "In ten years time it will be too late to get anything like the original components."

Weather Watch

What to buy the man or woman who has everything? How about a digital clock that doesn't need re-setting twice a year to cope with summertime?

Oregon Scientific (despite the name, a Far Eastern company) makes most of the travel clocks and electronic organisers that you see in mail order catalogues and chain stores. The RM-112 is a radio clock that automatically resets for summertime.

Long wave transmitters at Rugby in the UK, and Frankfurt for Continental Europe, continually transmit a very precise time signal. Radio receiver clocks use these signals for split second accuracy.

Hobbyists make these clocks from kits. Ready-made units have been expensive. However, Oregon has driven the price down to around £20.

Oregon's weather clocks also make cute gifts. They incorporate an electronic barometer, thermometer and humidity sensor, and integrate all these readings to predict weather trends. Prices range from about £40 to £100 depending on the number of l.c.d. display features. One unit bleeps to warn of a storm.

They all work well but Oregon has missed a trick, by not providing a simple explanation of barometric pressure, and how it can be used to predict changes in weather. We British are obsessive about weather, it's the national topic of conversation. But few people will actually know what a barometer measures, and why it is significant.

A barometer measures the pressure of the atmosphere, which extends around five miles above our heads. It's this pressure that lets you drink, by sucking through a straw. The weight of the air pushes the liquid up the straw.

The pressure changes as the atmosphere circulates over Continents. At the same time the amount of water in the atmosphere varies, changing with temperature but not in a linear fashion. This gives the relative humidity. Put them all together, compare the current readings with hourly readings over the last twenty four hours, and you get a fix on whether the weather is likely to change, and which way.

Barometers used to be made from a glass tube containing mercury, which rises or falls in a vacuum depending on the pressure. You have to tap the barometer tube, to stop the mercury sticking to the sides.

People with barometers tend to become obsessive tappers. Hence the old Swiss proverb, *Tapping the barometer won't change the weather.*

EPE ELYSIAN THEREMIN WITH MIDI BOX

JAKE ROTHMAN

PART 2

A full specification professional-grade instrument for the serious musicmaker

A BRIEF "potted history" of the Theremin from the early valve designs to the development of our dual, solid-state, version was introduced last month. We conclude this month by undertaking the construction and final "tuning-in".

CIRCUIT BOARD DESIGN

The circuit layout of Theremins is especially critical; after all, a circuit that can detect the capacitance of a hand a couple of feet away is not going to be happy with wires flapping about inside the case and Paxolin stripboard!

The design of the p.c.b. (printed circuit board) for this circuit was beyond the realms of the author's manual tape-up methods and this task was taken up by Adam Fullerton at Rosedene Audio with his skilled use of his CAD system. The topside component overlay, is shown in Fig. 14. This board is available from the *EPE PCB Service*, code 121.

In keeping with modern high frequency practice, large area ground (0V) and power rail (+V) planes are used to maximise screening to avoid spurious r.f. emissions and pickup. Plated-through-holes (p.t.h.) are used to avoid links and enable small pad sizes to be used for compactness, while retaining strength to allow the reliable use of board mounting potentiometers, switches and sockets.

AERIALS

It is essential that the aerial track lengths to the oscillators are as short as possible to maximise the sensitivity. The ground plane was also removed around the oscillator area for the same reason. It is also essential to minimise interaction between the two

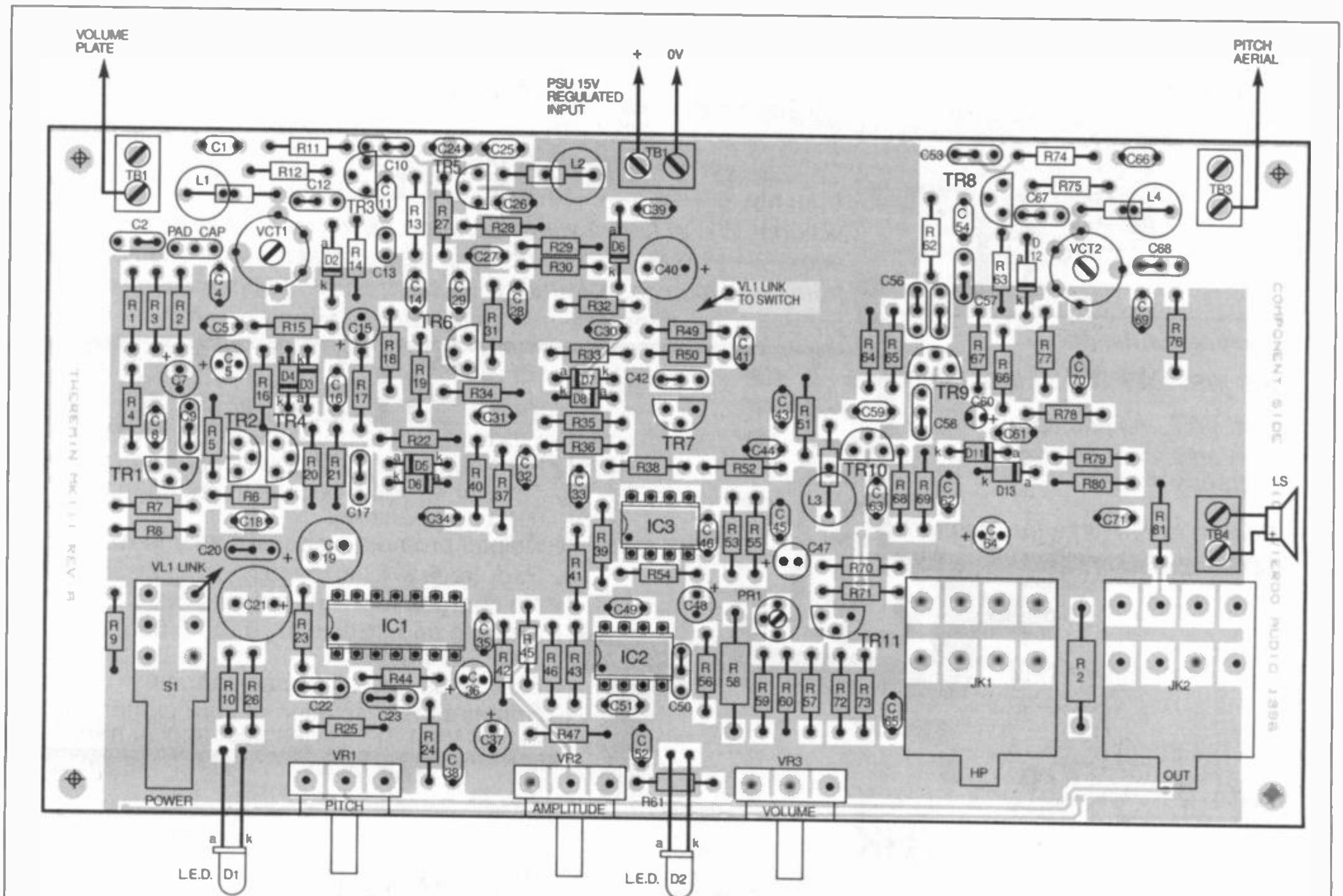


Fig.14. Printed circuit board component layout. This is a double-sided p.t.h. board.

"aerials" by keeping their entry points on the board as far apart as possible.

The way round all these conflicting requirements was to put the two aerial circuits at opposite ends of the board with the low frequency and d.c. circuitry in between. To stop r.f. bleeding into the audio, this section was placed right down at the front of the board to keep it away from the oscillators.

COILS

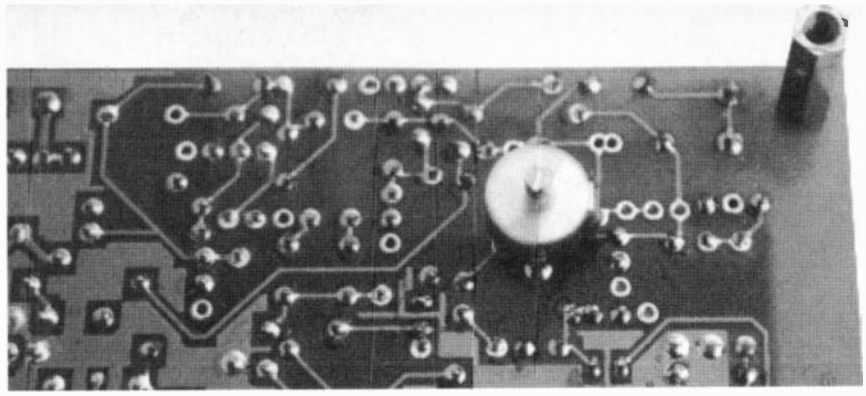
The Pitch oscillator coils are as far apart as practical and at right angles to each other to minimise coupling to put the lock frequency as low down as possible. The Volume oscillator coils, however, are on the same axis to give a degree of coupling. This ensures the oscillators lock at a reasonably high frequency to prevent the volume pulsing, which would occur at very low frequencies.

In common with good analogue design practice, no signals are routed through the front panel rotary pots. only d.c. control voltages. This means that the pots. can be positioned for maximum ergonomic advantage and long tracks used to connect them to their relevant circuit points if necessary. Using d.c. control also enables all the pots. to be the same value and linear, since it is simpler to implement any required law correction in the d.c. domain.

The p.c.b. is fed with a *regulated* d.c. power supply since any a.c., even the ripple on a basic smoothed d.c. supply, will cause modulation hum of the pitch. Another reason for leaving the regulator off the board was that its heat exacerbated problems with thermal drift.

CONSTRUCTION

Normal construction methods apply here, that is insert the components in height order. This means starting with the resistors. It is a good idea to solder the most common values in first (in this case, 14 1kΩ resistors) then move on to the next, since this minimises any errors in placing the more unusual values in place.



One of the trimmer capacitors soldered directly on the underside of the p.c.b.

The main points to watch are: first, it is much harder to remove components soldered in plated-through-holes, so watch out for those darned five-band resistors. A very common mistake with these resistors is to confuse brown and orange colour bands under tungsten or fluorescent light, halogen or daylight has much better colour rendering properties.

Second, l.e.d.s are about the only common components that can still be damaged by heat from soldering. Watch out for the diode pairs, some are pointing in opposite directions on the board, although the silk screened component identification should avoid any confusion here.

Note, all the transistors are BC182Ls which have the collector pin in the middle. BC182s without the L suffix will have to be bent round at a funny angle and their use is likely to cause errors.

It is sensible to put the i.c.s in sockets although a degree of heatsinking for the output chip can be obtained by soldering it directly onto the p.c.b. An unusual point to note is that the trimmer capacitors are mounted on the underside of the board since it looks better to have the adjustment holes in the bottom of the case rather than the top (see photograph).

There is one wire link, designated VL1, on the board carrying the power to the On/Off switch S1b. It is best to use a 125mm length of solid-core 1/0·6 red equipment wire. It can also be seen how to install the link from the photo below.

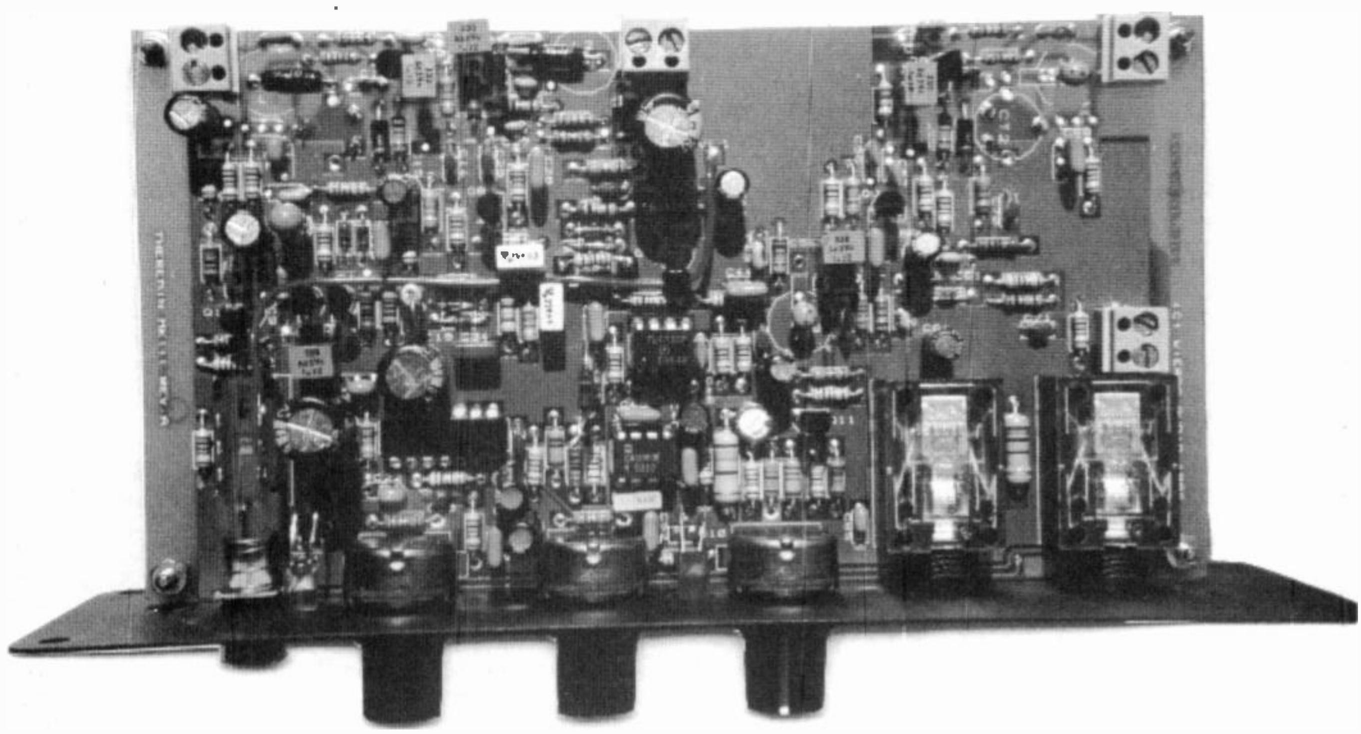
COMPONENTS

Standard wet aluminium electrolytics can be used throughout since they are all fully polarised. The only exception is C6 which should be *tantalum* or other dry type since it is only intermittently polarised.

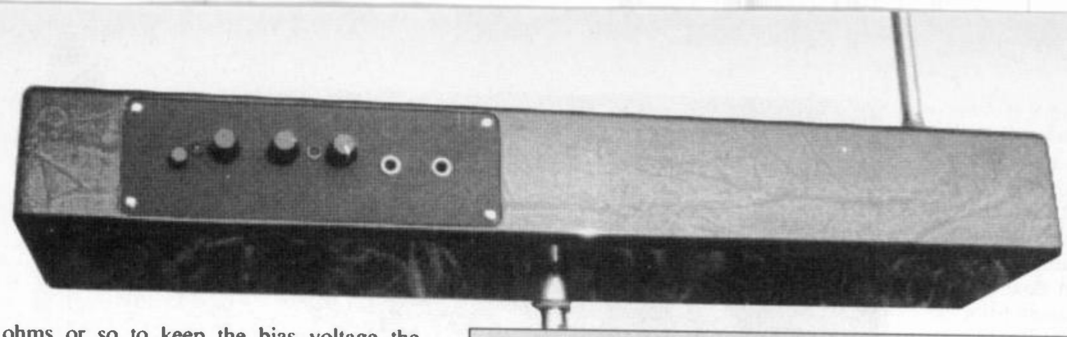
All the non-polarised capacitors are ceramic for their low inductance which makes them effective at bypassing r.f. The only exceptions are C31, C32 and C34 which are polyester and are used for timing of the volume control voltage, where the soakage effect of ceramics cause strange "handing-on" effects.

The p.c.b. is designed to accommodate both 0·1 inch and 0·2 inch non-polarised capacitors by the use of dual mounting holes. Take care that when using 2·5mm types that they are not inadvertently inserted into the two holes which are joined together. Since inductors come in all sorts of sizes, both axial and radial inductors can be used in the coil positions.

A "blue" l.e.d. is specified for D1 since it is in keeping with the mysterious nature of the Theremin. A normal l.e.d. can be substituted if resistor R10 is altered to 220



The completed double-sided, plated-through-hole, circuit board attached to the front panel. Note the power link wire from the push-switch to the board power pad VL1.



TAKE NOTE
Resistor R42 on circuit diagram should be 22k. Resistors R25 and R47 (Components List) should be 330k. VCT1, VCT2 5 to 55p trimmer capacitors and missing from Comp. List.

ohms or so to keep the bias voltage the same.

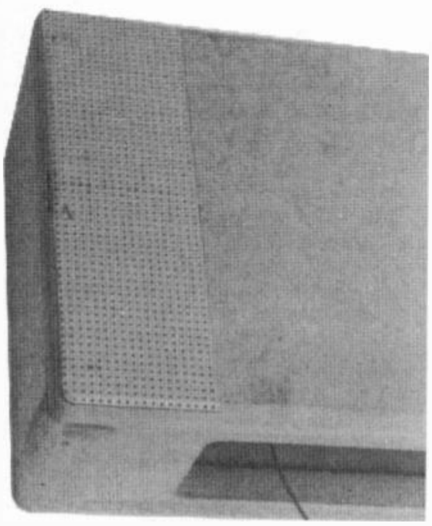
Schottky diodes are used for all the detector stages since their low forward voltage drop and soft turn-on characteristic give maximum output and lowest distortion. Any general purpose Schottky signal type can be used, with the BAT25 being the cheapest. Germanium types could be used but they tend to be less consistent.

Printed circuit board mounting rotary pots. should be used and the Alpha type are the most cost-effective and do not suffer from tag crimp failure like the more common Omeg variety.

The jack sockets are a special commercial type which have a proven contact reliability record in studio jack fields and can be supplied by the author (see *Shop Talk*).

CASE

It is essential that the case be made of some non-conducting material such as wood or plastic. The uses of a metal case would greatly impair the sensitivity of the



A piece of stripboard glued to one end of the case forms the Volume Plate.

instrument. If a metal front panel is used it must be "Earthed", better still use a plastic one.

If an earth is needed this can be connected to the spare earth pad on capacitor C28 if a 2·5mm component is installed. A piece of 22s.w.g. tinned copper wire can be used and looped around the bush of the Volume control VR2 to form a contact with the metal front panel.

The standard sort of case used in the model is shown in the photographs. The dimensions are shown in Fig.15. A Volume plate can be produced by using a piece of stripboard (38mm x 115mm).

INTERNAL WIRING

All external connections to the board are made through p.c.b.-mounting connectors (TBs) for ease of installation. It goes without saying that all wire runs must be

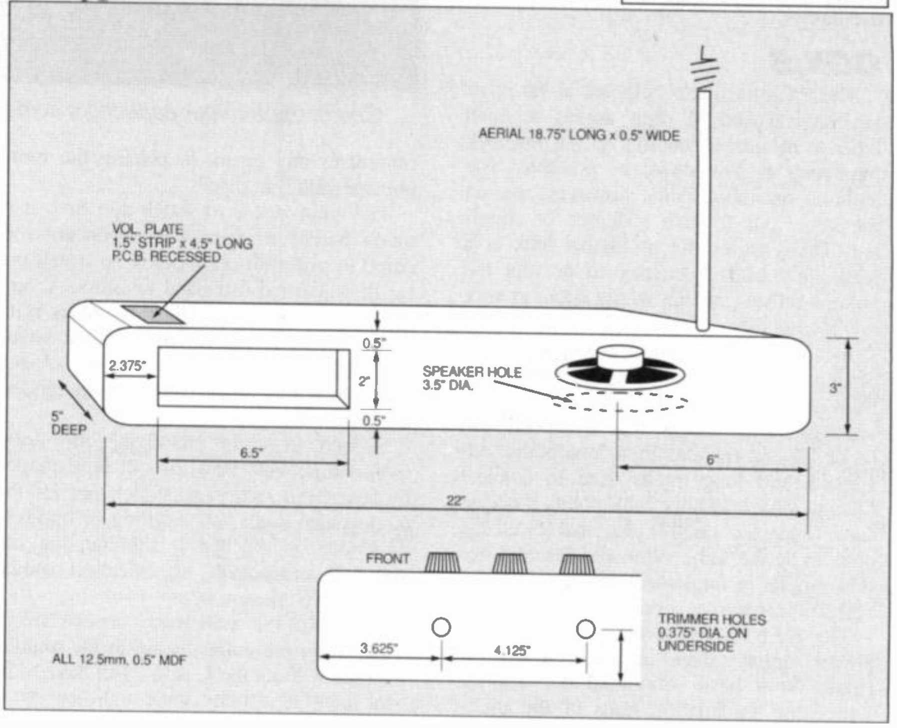


Fig.15. Dimensions and details for the Theremin case.

kept short and glued down along the box corners to avoid shifts in output due to movement.

SPEAKER

Since the output of IC1 is only a couple of watts into 8 ohms there is no point in using a high power hi-fi drive unit. In fact, such units are very insensitive and will not be loud enough.

A 2W paper-cone unit of over 3·5 inch diameter will work fine, low-colouration plastic-cone speakers do not sound as rich as a distorting flimsy paper cone. This is a situation applicable to electric guitar amplifiers as well.

It was found that 8 ohm speakers give best results since the chip gets too hot with 4 ohm and the power output is halved with 15 ohm. To get a louder sound it is worthwhile experimenting with porting the box.

AERIALS

To minimise interaction, the aerials operate in different planes. The Volume Plate is sensitive to vertical motion while the Pitch Aerial is sensitive to horizontal.

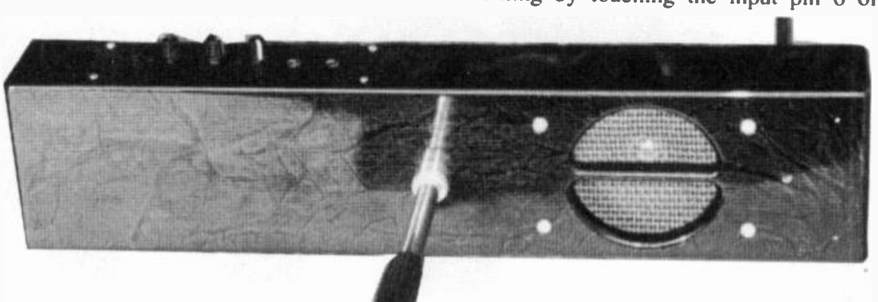
In fact, if the hand is moved up and down near the pitch aerial no change in pitch occurs. It is a common mistake for people new to the Theremin to move their hand vertically and wonder why nothing is happening. How the hands are normally placed while playing the Theremin is shown in last month's article.

The aerial mounting methods are also shown. Note that the wrought iron aerial gives better range than the "Do-It-All" aluminium tube.

ALIGNMENT AND TESTING

Do not expect the Thermin to work first time since there are so many variables and some tests and trimming are always required first.

As usual, the very first tests are the d.c. conditions, power rail, half-rail bias and output amplifier quiescent voltage. The next step is to verify the power amplifier is working by touching the input pin 6 of



Underside of Theremin showing speaker grille.

The speaker is mounted on a piece of board and inserted through the front panel aperture.

IC1 with a screwdriver and listening for hum.

It is essential the aerials be connected for testing or the oscillators will be too far apart in frequency, since the circuit takes into account the aerial capacitance.

The basic method of trimming Theremin circuits is to put the trim control in the middle of its rotational range and tweak the trimmer capacitor for the zero beat point. An insulated trimmer tool, such as the popular yellow Spectrol model, has to be used here. Using a *screwdriver* will cause a large frequency shift.

OSCILLATION

The most common cause of non-functioning Theremins is the oscillators being insufficiently close in frequency to produce an audible tone, making a frequency too high to be heard. In this situation an oscilloscope is essential to verify that the oscillators are working (note the probe must be set to × 10 to isolate the lead capacitance).

To find out which way the oscillators must be pushed in frequency, it is possible to use the trimmer capacitors VCT1 or VCT2 as a guide. If a faint high whistle is detectable (vanes fully enmeshed) more capacitance is needed on the fixed oscillator.

If this is not the case, it will be necessary to apply padder capacitors in turn to each oscillator. It is not effective holding the capacitors by hand or piers, it is essential to apply them by insulated means. The author has a collection of small two per cent ceramic plate capacitors from 4·7pF to 47pF glued into old Biro tubes for this purpose. If extra padder capacitors are needed they are fitted in positions C68 and C3.

It is sensible to get the Pitch oscillators (Fig. 10, last month) set up first before worrying about the volume side. While doing this the Theremin can be listened to by monitoring the continuous pitch output. Headphones can be used if desired.

VOLUME PLATE

Once the pitch side is working, attention can be focused on the Volume Plate. This is adjusted like the Pitch aerial in that the trim control is placed in the middle, and the trimmer capacitor is tuned to the zero beat point. It's a good idea to check the square wave at the collector of TR4 at this point.

The preset VR4 is used to trim out any variations in the turning-on point of the 3080 (IC2). To set it up, turn VR4 fully anti-clockwise and put the volume control VR3 at minimum.

While placing a hand near the Volume Plate, ensure the Orange l.e.d. D10 is on. There will be a point where the volume will just begin to come on as preset VR4 is turned clockwise. This sets the minimum volume for the Theremin and minimises any dead-band on the volume control.

CIRCUIT TWEAKS

Theremin circuits are generally very interactive and sensitive to component values and this circuit is no exception. Some much more complex designs can avoid this by buffering between every stage, but this will double the component count.

However, interactive circuits can be extensively "tweaked" (if time is available) to give synergistic effects that can make them very cost effective.

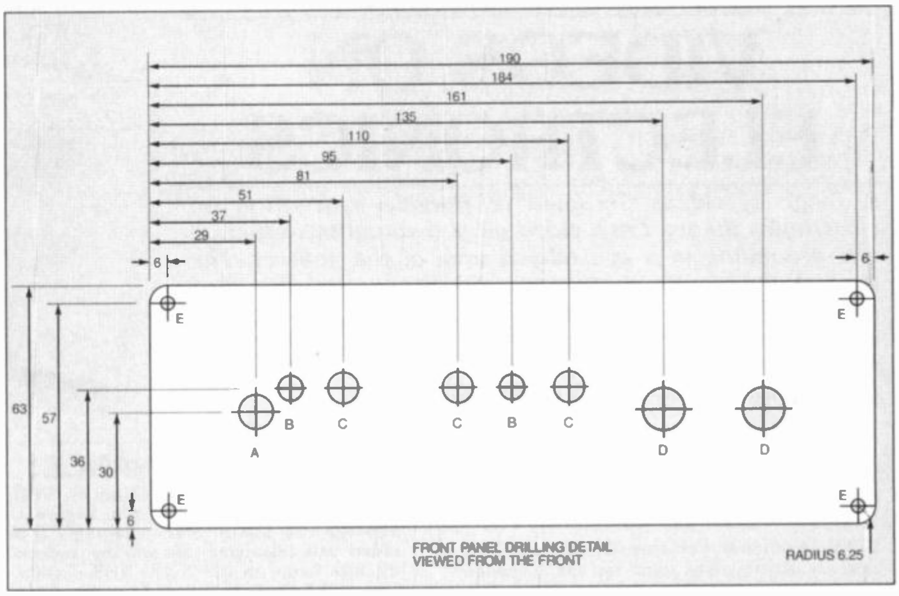


Fig.16. Control mounting front panel drilling details and measurements.

FREQUENCY RESPONSE

The audio frequency response of the Theremin rolls-off at approximately 6dB/oct from about 100Hz. This is to compensate for the small loudspeaker used in the box, the increased sensitivity of the ear at mid-range frequencies and as a consequence of the r.f. filtering.

It is possible to engineer a flatter response by lacing a top-boost filter network consisting of a 15nF capacitor and a 13k resistor, in series, placed in parallel with resistor R41. Note that R41 must be increased to 39k to compensate for the network if fitted.

The Theremin MIDI unit (starting Jan'97 issue) works better with a flat frequency response, this can be done by adding a network consisting of a 6n8 capacitor and a 3k3 resistor in parallel with the lower arm feedback resistor (R54) of the op.amp IC3.

AERIAL RANGE

It is possible to extend the range of the aerials by inserting loading coils in series. Around 4·3mH seems to give optimum improvement of the pitch range. Unfortunately, such coils need to be of very low self-capacitance and standard types do not work.

Wave-wound multi-sectioned types similar to the radio frequency chokes (r.f.c.s) used by radio constructors, which were available in the past, work. It may be possible to try old Repanco CH2 5mH types, *if they can still be found.* Old long-wave radio ferrite rod aerial coils may also work.

TEMPERATURE COMPENSATION

The circuit as it stands is sensitive to temperature variations and needs to be left on for some time to warm up and achieve stability. Obvious considerations have been taken into account such as keeping the oscillators away from components emitting heat. Also, the capacitors used in the oscillators have been specified to have a *negative* temperature coefficient to partly cancel the positive temperature coefficient of the coils.

However, there are thermal drifts due to the board material, resistors and the internal capacitances of the transistors themselves. By using special r.f. transistors, where the capacitances are predictable and specified, in place of the ubiquitous BC182s, stability could be improved. It is possible to obtain ceramic plate capacitors with quite high negative temperature coefficients of 750 ppm (denoted by a purple band across the top on the Philips types) and these could be used to provide compensation.

CRYSTAL CONTROL

By replacing the fixed oscillators with crystal controlled types, stability could be greatly enhanced at increased cost. However, there is the problem of obtaining pure sine waves using crystals, most crystal oscillators produce squarewaves.

DIGITAL THEREMINS

Some attempts have been made to apply digital techniques to the Theremin. One idea of the author's is to run the basic Theremin circuit at a much higher frequency then divide it down digitally to get a greater range.

Microprocessor control could also be used to provide feedback control to enforce stability in all situations. The question is, once one is far removed from the two r.f. sinewave oscillators beating together, is it a Theremin anymore?

SOUND CHANGES

Since volume and pitch are voltage controlled it is a simple matter to add Tremolo and Vibrato if required by driving the "varicap diodes" with low frequency oscillators (l.f.o.s). Reverb greatly improves the sound, and the old Springline Units work very well in this application, since high bandwidth and good transient capability are not required. Extra harmonics can be added by diode clipper fuzz boxes and the like followed by a parametric equaliser.

Of course, to get the widest range of sounds the Theremin signals have to be converted to MIDI/CV so that any synthesizer can be driven. This can be accomplished by using Adam Fullerton's MIDI/CV Box starting next month. □

VIDEOS ON ELECTRONICS

A range of videos designed to provide instruction on electronics theory. Each video gives a sound introduction and grounding in a specialised area of the subject. The tapes make learning both easier and more enjoyable than pure textbook or magazine study. They have proved particularly useful in schools, colleges, training departments and electronics clubs as well as to general hobbyists and those following distance learning courses etc.

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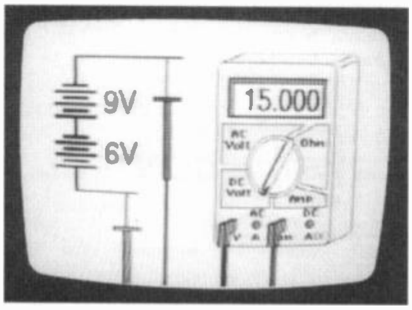

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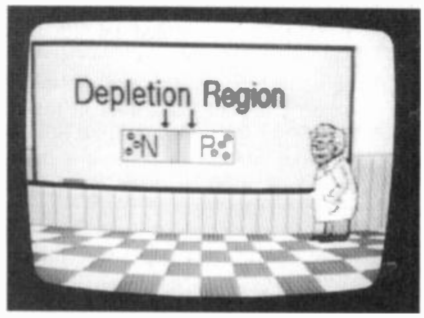

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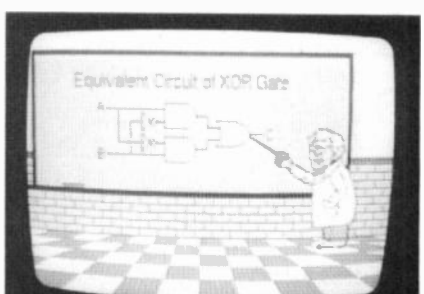

Each video uses a mixture of animated current flow in circuits plus text, plus cartoon instruction etc., and a very full commentary to get the points across. The tapes are imported by us and originate from VCR Educational Products Co, an American supplier. (All videos are to the UK PAL standard on VHS tapes)

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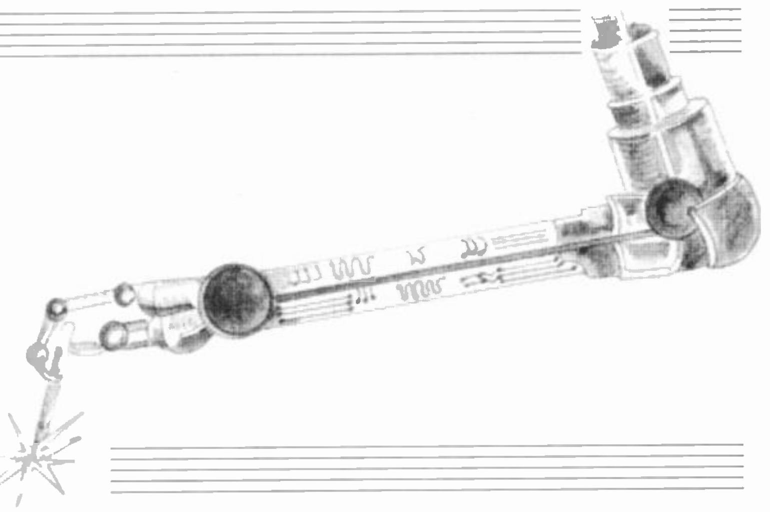

ALAN WINSTANLEY

Our monthly* "Surgeon" *helps out with a boat owner's electrical woes.

Berserk Bargraph

Following on from last month with another troubleshooting story, I'm grateful to ***Mr. Eric Forrester*** of Hemlington, Cleveland who dropped a line as follows.

Your Circuit Surgery *September 1996 issue shows a Car/Boat Battery Monitor but this had me perplexed owing to your Dial Light arrangement. I constructed the circuit on stripboard but it is not dimming the l.e.d.s, and also the bargraph reads values different from those you indicate in your circuit diagram!*

This chip is new to me and I'd appreciate some help – enclosed is my Veroboard layout diagram which I designed, could you take a look? I can't quite figure out the calculations for the potential dividers, either.

No problem! After a few minutes of peeking through my magnifying glass, I spotted the cause of the l.e.d. problem, which I attributed to incorrectly identifying the pins of the LM3914 i.c. – Fig. 1 shows how to identify the pins of this dual in line chip. Notice that either a dimple or

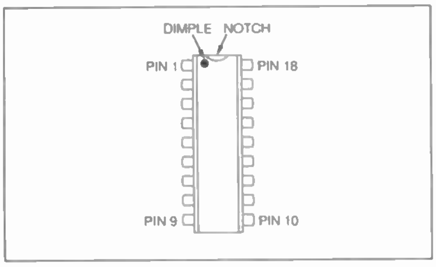

Fig. 1. An 18-pin d.i.l. integrated circuit package pin line-up.

a notch will identify one end of the device, and also the positive and negative supply pins 2 and 3 are (unfortunately) adjacent to each other; errors wiring them reversed to the supply will spell death to the chip!

You are not alone, Mr. Forrester, because the pin numbering sequence of a dual-in-line chip does often confuse newcomers. The other point in this respect concerns the circuit diagram shown on P.682 of the September issue. We always show the pin numbers on the outside of the i.c. symbol, and anything denoted *within* the rectangle represents the pin *function*, not number.

The Dial Light function worked well on test: the idea is that each resistor R5-R14 is connected to one of the l.e.d.s. in the display, and all the resistors are commoned to 0V via the switch. High value resistors are used and I tried 10k to 33k with success. They enable a small current to flow through each l.e.d. to 0V, so that each l.e.d. glows dimly. When its corresponding LM3914 output goes low, this permits a much greater current to flow through the l.e.d. which glows more brightly than the others. The effect is to create a "backlit" l.e.d. scale.

If you use high efficiency l.e.d.s., these require only a few milliamps to operate, and they offer a proportionately greater light output compared with vanilla-flavour devices. To enable the LM3914 to be cascaded to make larger displays, the

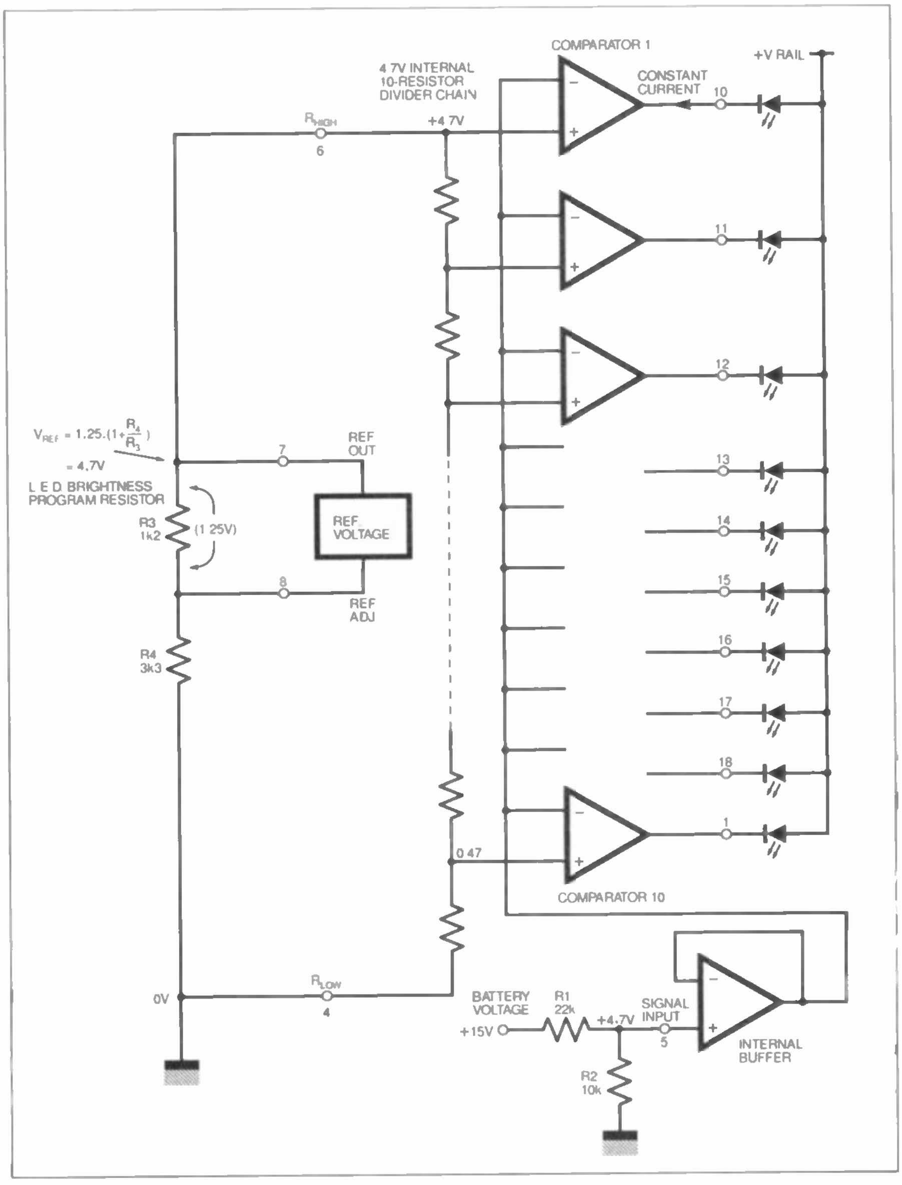

Fig. 2. Simplified block diagram for the LM3914 linear l.e.d. driver.

internal circuitry of the chip causes at least 100µA to flow through the l.e.d. connected to pin 1. So even if that l.e.d. should logically be switched off, this extra sink current may be adequate to cause D10 to glow faintly (assuming you use the l.e.d. at all in this design). The remedy is to shunt it with a parallel 10k resistor if this is a problem. Trying the circuit for myself with high efficiency l.e.d.s (before the Dial Light idea came about), I did indeed see D10 glowing continually because of the special circuitry at pin 1. A rummage through the Data Book revealed why!

Calculated Guess

Turning to the calculations behind the circuit, firstly I made use of the chip's adjustable reference voltage which is available at pin 7. Fig. 2 shows a simplified block diagram of the LM3914. It features a chain of resistors, each tapped and connected to a comparator, one per l.e.d. One end of the chain is labelled R_{HIGH} (pin 6), the other R_{LOW} (pin 4). The voltage applied across the resistor chain determines how sensitive the LM3914 will be to input voltages: apply 10V across the ends, for example, and each l.e.d. will represent 1V.

The internal reference voltage is preset at 1·25V, meaning that each l.e.d. represents 125mV. I wanted a full-scale deflection of 15V in 1·5V steps, so I increased the reference voltage with the resistors R3 and R4. (Note that the current drawn out of pin 7 also sets the l.e.d. brightness. Since 1·25V exists between pins 7 and 8, the l.e.d. current is actually ten times more than this, i.e. 10mA. I always tend to set R3 at 1·2k.) In fact when designing the circuit, I worked backwards from the input requirements, and set the reference voltage to suit, as follows.

If V_{IN} = 15V, therefore V_{SIG} = 4·7V roughly at pin 5. This means that the i.c. input signal sees about one third of the actual battery voltage measured, due to the potential divider action of R1 and R2. The i.c. reference is calculated by:-

$$V_{REF} = 1{\cdot}25(1 + \frac{R_4}{R_3})$$

so the reference voltage applied across the resistor cascade was also set for 4·7V using the values of R3 and R4 shown. You'll see how this 4·7V reference voltage at pin 7 is connected to R_{HIGH} at pin 6, whilst R_{LOW} is grounded. Hence, each l.e.d. represents approximately 0·5V change in the input signal at pin 5, which scales up to approximately 1·5V battery voltage change. Ten light-emitting diodes therefore appear to read the battery voltage, up to 15V. Incidentally the input circuitry of the LM3914 is fully protected up to 35V in any case: but by scaling the bargraph with the reference voltage (and input dividers), you can obtain more suitable displays. I hope this helps.

Ohm Sweet Ohm

Max Fidling

What a Pantomime

Many a time, the village Reverend has called upon me to cobble together various bits of paraphernalia which form part of his *Church Bells* mobile discotheque, and gradually he'd weaned my highly-honed skills onto the annual Christmas Pantomime held each December in the village hall.

I obviously had my idiot light switched on when the job was given out, but it's worth it for the home-baked mince pies and sherry which are dished out freely by the Reverend's wife afterwards. So anyway, this year's blockbuster was to be *Dick Whittington and his Cat* and yours truly was at the controls once again, readers!

Because church funds had been stretched farther than the bell ropes can dangle, the Reverend often looked upon me to improvise and many a time I've pressed some surplus bits of equipment from the shack into service for the benefit of the Reverend s fund-raising events.

Heavenly Light

A couple of years previously, I'd managed to construct a very small lighting desk for the Rev. which consisted of a plywood box into which I had installed a handful of dimmer switches to control the lighting (six 500W floodlights), and this gadget was proudly displayed by the Reverend at each subsequent event.

It looked very purposeful, with six round-pin Bakelite sockets labelled 1, 2, 3, 7, 8, 9 (I'd lost the stickers saying 4, 5 or 6) where the lights were connected, and a neon pilot lamp glowing when the circuit was live. The Reverend also used it when the *Church Bells* disco performed live in concert.

There was however a snag. I hadn't actually bargained on being the lighting director for the Christmas play, but as usual, helped by the Boss, I'd been landed with the job!

However, all I had to do was switch the lights on and off when cued by the Reverend, ready for them to change scenes, and so for a week or two I ambled over to the odd rehearsal armed with a flask of tea and the latest copy of *EPE* to read in between times, whilst the various celebrities from the village played their parts with gusto, directed by the Reverend as always.

The fateful week finally arrived, the amateur cast having got to grips with their lines and yours truly mastering all six floodlights, and having perfected my timing to the nearest few minutes, give or take a bit.

A Timely Manna

I was determined not to get caught out as I had been in previous years, though, because experience had taught me to prepare for long spells of boredom in the chilly village hall in between switching the lights, and so I'd brought a Thermos of tea, and chocky bikkies, and by way of a treat I'd also brought my cat, Piddles, along with me, who could be relied upon to liven up proceedings.

The evening's events progressed with the audience assembling amidst a great clamour of clattering chairs, coughing, shuffling and excited chattering. Eventually, with everybody settled, the Rev. signalled for me to turn up the stage lights, at which point he switched off the front-of-house lights one by one. I rotated the small dimmer switches and the tiny stage illuminated on cue, and the life history of *Dick Whittington* started to unfold.

After fifteen minutes or so it was time for a cuppa, I reckoned, so the trusty Thermos was unstoppered and a plastic beakerful of the cheering brew quaffed. This was to be the pattern of events for the next hour and a half as I twiddled the dimmers whenever the Reverend signalled, and rustled my packet of biscuits in between times, too. Piddles looked up every now and then, quite uninterested in the proceedings.

After a few more chaotic scene changes backstage, I'd decided to unroll the copy of *EPE* I'd stuffed into my coat pocket, and it was time for some serious reading, biscuit-munching and tea drinking, I told the cat.

Without Catcalls

The good old lighting desk worked great, and everything was going to plan with the audience enjoying the story of *Dick Whittington and his Cat*. This was until Piddles decided to stir from his slumbers and start fidgeting, a sure sign that he's hungry! Hurriedly, I proffered the moggie a bikky as a bribe to stop him from wailing, which is normally the next tactic in his scheme when demanding his grub! What a time to become hungry!

I could hardly gag the poor puss (sorely tempted though I was), but then, the Rev. signalled for the lights to be dimmed once more! At this point, Piddles nudged the Thermos flask which nearly tipped over onto the lighting desk. I rescued the vacuum flask just in time as Piddles then wandered out from behind the scenes, on stage!

I tried to grab him by reaching out from the wings, but missed! It was too late, Piddles was a superstar! Quite what the cast thought of the unscheduled entrance of this feline understudy I'm not sure – but the audience thought it was hilarious! And I didn't even get my sherry and mince pie.

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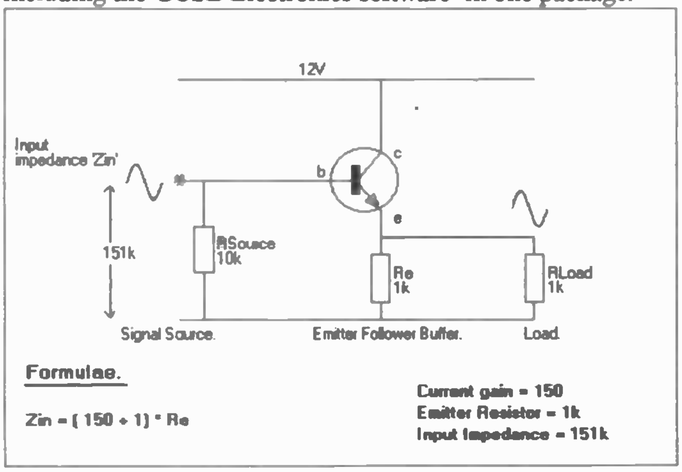

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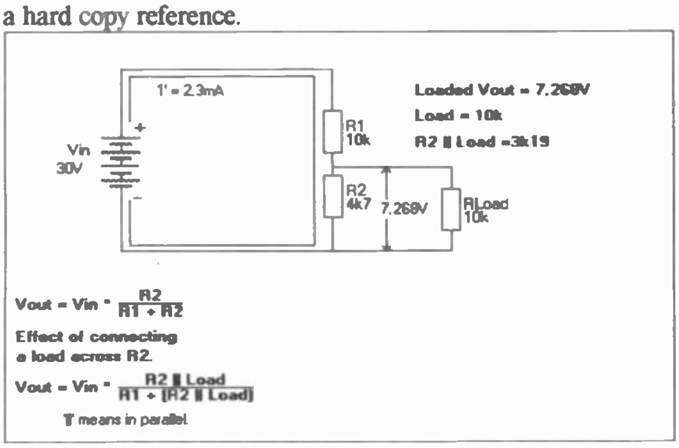

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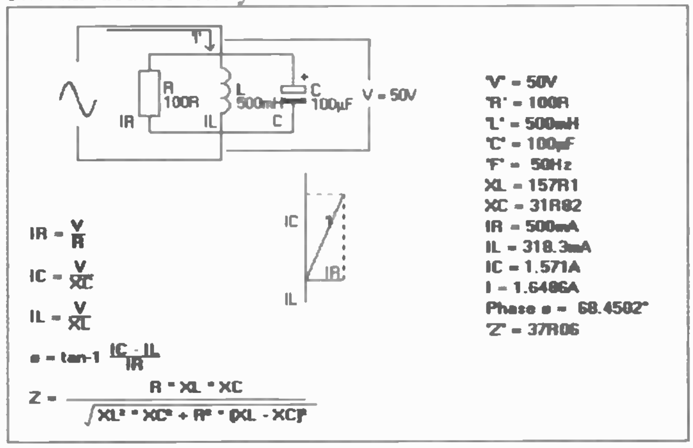

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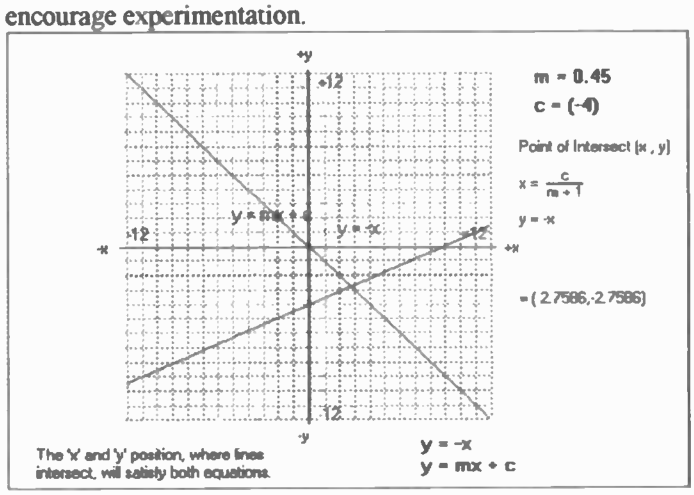

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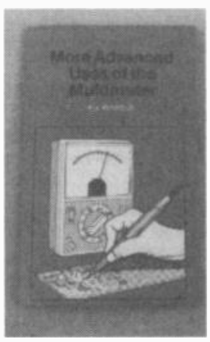

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NOTE: While 95% of our boards are held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail.

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Software programs for the following *EPE* projects (PIC-microcontrolled except for Met Office and Central Heating Controller) are available altogether on a *single* 3·5 inch PC-compatible disk, or as needed, via our Internet site: Met Office (Dec '95) – GWBasic; Simple PIC16C84 Programmer (Feb '96); PIC-Electric Meter (Feb '96); PulStar (June '96); Games Compendium (July '96); PIC-Tock Pendulum Clock (Sept '96); PIC Disassembler (unpublished); Central Heating Controller (Nov '96) – 8051 machine code; PIC Digital/Analogue Tachometer (Dec '96). The disk (order as "PIC-Disk") is available from the *EPE PCB Service* at £2.50 (UK) to cover our admin costs (the software itself is *free*). Overseas £3.10 surface mail, £4.10 airmail.
Alternatively, the software files can be downloaded *free* from our Internet FTP site: **ftp://ftp.epemag.wimborne.co.uk**

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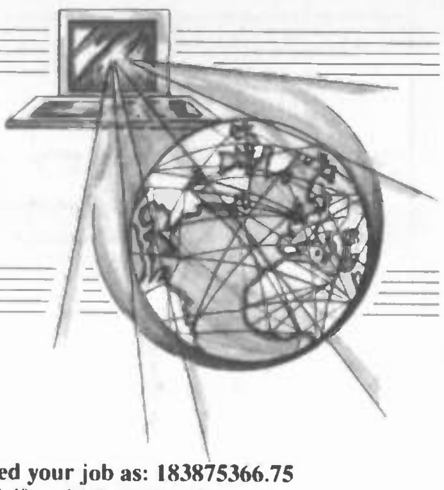
ALAN WINSTANLEY



THOUSANDS of users from forty countries visit our World Wide Site every week at **http://www.epemag.wimborne.co.uk**. Whether you live in Taiwan or Trinidad and Tobago, welcome to *EPE*!

Our Web site is continuing to expand, with Back Issue information and ordering details going on-line in the near future (hopefully by the time you read this). Please do drop in from time to time to see what's new. Subscription details, and the on-line version of *Net Work*, are there as always, and we welcome your suggestions and comments.

New on our FTP site (**ftp://ftp.epemag.wimborne.co.uk**) are the files for the *Central Heating Controller* project (Nov. '96 issue), to be found in the **pub/Heating** sub-directory. This month's *PIC Digital/Analogue Tachometer* can be found at **pub/PICS/Rev.Counter**. I've uploaded the source code file for the *National Lottery Predictor* (April '95) project to the **pub/PICS/Lottery.Predictor** sub-directory. Thanks to its author Julyan Ilett for sharing the file with us. There is also a new, smaller **nicad2.zip** file in **pub/docs/** which discusses Ni-Cad cell terminal voltages.

Get the most from your post

I'm acutely aware that many readers reside in countries where full-scale Internet access is still some way off. Indeed, as my postbag proves, a substantial number of our "wired" readership barely have access to E-mail, let alone other services such as World Wide Web and FTP.

File Transfer Protocol (FTP) was fully described in *Net Work* October '96 issue, as a means of transferring or downloading interesting computer files from a "remote" machine onto your own "local" computer. To do this, it's best to use an FTP program on your own computer which will give you full control over the transfer process.

You can use ordinary E-mail to help handle your FTP requirements, though. It's not reliable with very large files (say, over a few hundred kilobytes) but it saves you having to go on-line, connect to the remote FTP site and fetch the files for yourself. Instead, you send a brief, simple E-mail message to an *FTPmailer* computer. The FTPmailer will then go away, find the file, and very generously send it to you as an E-mail!

A typical E-mail request contains a small script of the Unix commands needed to instruct the FTPmailer where to go, and what to do when it gets there. For instance, on our FTP server there's a text file called **epe_info.txt** which is stored in the **pub/docs/** directory. Here's an example of file retrieval using such an FTPmailer:

First choose which FTPmailer you're going to use: you'll find it faster and more reliable to use one in or near to your country, which avoids loading other FTPmailers dotted around the planet. In the UK, the address is **ftpmail@doc.ic.ac.uk** so an E-mail is sent there, with no subject or signature, as follows (my notes in brackets):

open ftp.epemag.wimborne.co.uk (find our FTP site)
cd pub/docs (Change Directory to **pub/docs**)
get epe_info.txt (fetch the file and mail it to me)
quit

The above simple E-mail message is sent to the FTPmailer at the Dept. of Computing, Imperial College, London. It sends an acknowledgement response soon afterwards, as follows:

ftpmail has received the following job from you:

reply-to alan@epemag.demon.co.uk
open ftp.epemag.wimborne.co.uk anonymous alan@epemag .demon.co.uk
cd pub/docs
get epe_info.txt

ftpmail has queued your job as: 183875366.75
Your priority is 1 (0 = highest, 9 = lowest)
Requests to sunsite.doc.ic.ac.uk will be done before other jobs.
There are 130 jobs ahead of this one in the queue.
4 ftpmail handlers available.
To remove send a message to ftpmail@sunsite.doc.ic.ac.uk containing just: delete 183875366.75

Note that I can cancel the request by mailing the ID number shown, and also see how it picked up the "anonymous" FTP password automatically. Otherwise, the file will arrive by E-mail, though you must allow anything from under an hour to a day or more.

There may well be size restrictions involved with some FTPmailers, so don't waste your time trying to get the latest huge version of *Netscape* mailed to you! The main point is that obviously you need to know the *exact* address of the file you're interested in.

Also, play safe and include the command **binary** if you are fetching ZIP files, graphics, programs or similar.

Here's a list of some of the other FTPmailers:

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ftpmail@sunsite.unc.edu (USA)
ftpmail@ftp.uu.net (USA)

I have to say that FTP by E-mail doesn't always seem to work, which might be due to the workload placed on servers at peak times. Hopefully this will still help add a new dimension to your vanilla E-mail connection though. Practise on our FTP site!

Links

Jump to the *Net Work* page on our WWW site for these electronics-related links which are there, ready-made for you: another for CE-engineers, the *EMC and Safety FAQ* is at **http://world.std.com/~techbook/compliance_faq.html**. Enthusiast Gareth Downes-Powell asks me to point you all at his new WWW project which he hopes will become a full resource for PIC 16C84 users. It looks excellent, and it's on **http://dspace.dial.pipex.com/town/parade/nx22**.

Calling Amiga users! The Amiga Software Archive is a full mirror of all available Amiga software (it says here) held on the Imperial College Sun Site at **http://src.doc.ic.ac.uk/aminet/info/www/home-src.doc.html**.

Interested in Mind Entrainment (as used in the series of *EPE Mind Machine* projects)? Try **http://www.mind-gear.com** for the low-down on "mental fitness technology". Cheers to Dave Preston for: **http://www.triton.cc.il.us/elecmisc.html** which points to several Electronics WWW Pages and FAQs. Also, **http://www.cera2.com/srcnet.htm** is an *Electronics Search FAQ – Finding Electronic Design Information on the Internet*.

Also, **http://ftp.unina.it/pub/electronics/REPAIR/index. html** is the European mirror for the *Sci.Electronics.Repair FAQ* where there are absolutely masses of worthwhile resources on the subject of repairing appliances and gear. Thanks to Massimo Gais in Naples for this. If you have any sites you'd like to share with your fellow readers, please let me know by E-mail. See you soon for more *Net Work*.

My E-mail address is **alan@epemag.demon.co.uk**

EVERYDAY PRACTICAL ELECTRONICS

The No 1 Magazine for Electronic & Computer Projects

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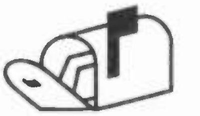

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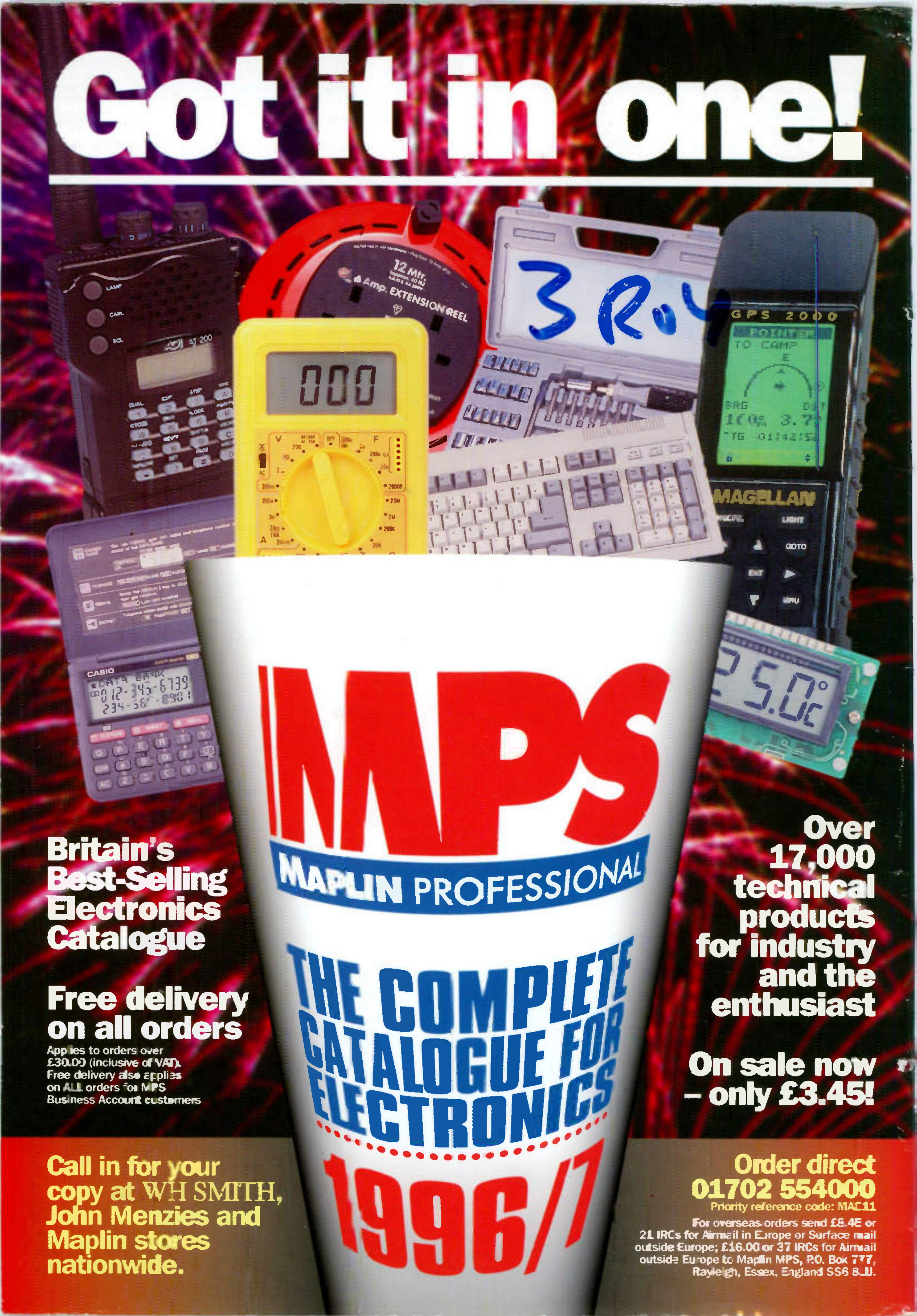
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